CLERK'S COPY.

Vol. I

TRANSCRIPT OF RECORD

(Pages 1 to 368)

Supreme Court of the United States

OCTOBER TERM, 1947

No. 280

FUNK BROTHERS SEED COMPANY, PETITIONER,

vs.

KALO INOCULANT COMPANY

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SEVENTH CIRCUIT

PETITION FOR CERTIORARI FILED AUGUST 19, 1947.

CERTIORARI GRANTED OCTOBER 13, 1947.

IN THE

Supreme Court of the United States

OCTOBER TERM, 1946.

No.

FUNK BROTHERS SEED COMPANY,

Petitioner,

vs.

KALO INOCULANT COMPANY,

Respondent.

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SEVENTH CIRCUIT.

INDEX.

Index to printed record of proceedings in U. S. District Court i

Clerk's Certificate to Vol. I of printed record of proceedings in U. S. District Court 368a

Clerk's Certificate to Vol. II of printed record of proceedings in U. S. District Court 813

INDEX TO PROCEEDINGS IN COURT OF APPEALS.

Placita 815

Order taking cause under advisement, entered May 8, 1947 816

Opinion by Lindley, J., filed June 12, 1947 817

Judgment No. 9040, entered June 12, 1947 834

Judgment No. 9041, entered June 12, 1947 835

Petition to stay Mandate, filed June 27, 1947 836

Order staying Mandate, entered June 27, 1947 837

Clerk's Certificate 839

Order allowing certiorari 840

VOL. I pp. 1 to 368

TRANSCRIPT OF RECORD

IN THE

United States Circuit Court of Appeals

FOR THE SEVENTH CIRCUIT

KALO INOCULANT COMPANY,
Plaintiff-Appellant,

No. 9040 vs.

FUNK BROTHERS SEED COMPANY,
Defendant-Appellee.

KALO INOCULANT COMPANY,
Plaintiff-Appellee,

No. 9041 vs.

FUNK BROTHERS SEED COMPANY,
Defendant-Appellant.

Appeals from the District Court of the United States for the Southern District of Illinois, Southern Division.

TRANSCRIPT OF RECORD FILED MARCH 4, 1946.
PRINTED RECORD.

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Defendant-Appellant.

Appeals from the District Court of the United States for the Southern District of Illinois, Southern Division.

INDEX—9040

	PAGE
Placita	1
Complaint, filed Dec. 10, 1943	2
Answer and Counterclaim, filed Jan. 26, 1944	5
Reply to Counterclaim, filed Feb. 14, 1944	13
Amended Answer, filed Oct. 28, 1944	15
Order setting cause for trial, entered Apr. 30, 1945	17
Order resetting cause for trial, entered May 14, 1945	17
Stipulation re: Patents, etc., filed June 25, 1945	18
Stipulation re: Claims, etc., filed June 25, 1945	19

REPORT OF PROCEEDINGS.

Plaintiff's Interrogatories	27

WITNESSES FOR PLAINTIFF.

Testimony of:

Bond, Varley Sherman	34, 353
Burris, Robert H.	345
Curie, Irvin Harold	21
Lusk, Myron E.	138
Umbreit, Wayne William	338

WITNESSES FOR DEFENDANT.

Testimony of:

Curie, Irvin Harold	153
Erdman, Lewis W.	220
Hofer, Alvin William	300
Leonard, Lewis Thompson	289
Manns, Dr. Thomas Franklin	243

PLAINTIFF'S EXHIBITS.

NO.		Introduced in Evidence at page	Reproduced at page
1.	Package of "Legume-Aid" inoculant for clover and alfalfa	22	369
2.	Bond Patent No. 2,200,532	26	769
3.	Chart headed "Source of Stock Strains"	68	371
4.	Chart headed "Nodulation Test"	68	374
5.	Chart headed "Efficiency Test for Nitrogen Fixation"	68	375
6.	Chart headed "Importance of Efficiency Tests"	68	377
7.	Chart headed "Preparation of Humus Type Culture"	68	379
8.	Can of "Uni-Culture" Humus of Plaintiff	68	
9.	Can of "Uni-Culture" inoculant for clover, alfalfa and soy beans	68	
10.	Chart entitled "Effect of Inhibition in Mixed Culture"	68	381
11.	Translation of Praktische Blatter, headed "On Mutual Retardation and Favoring Between Nodule Bacteria," by Max Kronberger	68	383
12.	Pamphlet entitled; "Division of Bacteriology, Progress Report of The Dominion Agricultural Bacteriologist," by A. G. Lockhead for years 1931, 1932 and 1933	68	395
13.	Pages of book entitled, "Root Nodule Bacteria and Leguminous Plants"	68	397
14.	Photograph headed "Clover, 40 Plants Each Group"	91	402
15.	Photograph headed "Soy Beans, 8 Plants Each Group"	91	404
16.	Chart entitled "Reduction in Yield of Red Clover Due to Inhibition"	94	406

NO.		Introduced in Evidence at page	Reproduced at page
17.	Letter July 29, 1938, Lusk to Matchette	146	408
18.	Letter July 29, 1938, Hofer to Bond...	326	410
19.	Letter July 19, 1938, Hofer to Bond...	327	412
20.	Title page and pages 14 and 15 of 1938 Lockhead publication	327	416
21.	Letter May 18, 1945, Hofer to Conn...	335	422
22.	Translation of article by Prof. Dr. Gerlach and R. Vogel, entitled "Observations on the Action of Hiltner's Pure Cultures for Legumes".....	338	423

DEFENDANT'S EXHIBITS.

1.	"Culture Chart and 1932 Price List" as to moist powder humogerm, a humus base legume inoculant made with farmogerm bacteria	241	437
2.	Package labeled "Inoculation, McQueen's Inoculator, Good for Sweet Peas—Lupines, Garden Peas and Beans	241	
3.	Photograph showing front and back of Package—Defendant's Exhibit No. 2..	241	440
4.	Advertisement and Wholesale Price List effective July 15, 1937—Season 1937-1938, of McQueen's, Inc.....	241	442
5.	Summary headed "Efficiency of Clover Bacteria as Affected by Alfalfa Bacteria, dated Oct. 27, 1944.....	337	446
6.	A—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 202," heading below "Plus 12 Strains Alfalfa Bacteria"	337	447
6.	B—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A1," heading below "Plus 12 Strains Alfalfa Bacteria"..	337	449

No.		Introduced in Evidence at page	Reproduced at page
6.	C—Photograph showing two rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A2," heading below "Plus 12 Strains Alfalfa Bacteria"	337	451
6.	D—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A3," heading below "Plus 12 Strains Alfalfa Bacteria"	337	453
6.	E—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A4," heading below "Plus 12 Strains Alfalfa Bacteria"	337	455
6.	F—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A5," heading below "Plus 12 Strains Alfalfa Bacteria"	337	457
6.	G—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A6," heading below "Plus 12 Strains Alfalfa Bacteria"	337	459
6.	H—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2B1," heading below "Plus 12 Strains Alfalfa Bacteria"	337	461
6.	I—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2B2," heading below "Plus 12 Strains Alfalfa Bacteria"	337	463

NO.		Introduced in Evidence at page	Reproduced at page
6.	J—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2B3," heading below "Plus 12 Strains Alfalfa Bacteria"	337	465
6.	K—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2B4," heading below "Plus 12 Strains Alfalfa Bacteria"	337	467
6.	L—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "12 Strains Clover Bacteria," heading below "Plus 12 Strains Alfalfa Bacteria"	337	469
7.	Document entitled "The Effect of Nodule Bacteria Rhizobium Meliloti on the Activity of Clover Nodule Bacteria Rhizobium Trifolii," by I. H. Curie	338	471
8.	Document entitled "Bond Patent No. 2,200,532; Nitrogen Fixed per 10 Plants Clover, etc."	241	473
9.	Letter June 30, 1941, Curie to Bachelor	241	475
10.	Advertisement "Nitragen Facts That Bear Great Weight," dated 1923, and showing prices of the Nitragen Company, Inc., of Milwaukee, Wis., giving miscellaneous cuts, price cuts and other information	241	476
11.	A—Photograph of can bearing the wording "Nobbe-Hiltner Process, Nitragen for Garden Peas, Garden Beans, Sweet Peas and Lupines, Good until December 31, 1935"	241	478
11.	B—Photograph of can showing the wording "The Original Legume Inoculator, Nitragen," etc.	241	478

NO.		Introduced in Evidence at page	Reproduced at page
11.	C—Photograph of can showing the word "Directions" and the wording "Use Only for Seeds Stated on Top Label, etc."	241	480
11.	D—Photograph of can, side view, showing the word "Caution," etc. and the word "Guarantee," etc.	241	480
12.	Can labeled "Nitragen," of The Nitragen Company, Inc., Milwaukee	241	
13.	Report of Lewis W. Erdman, headed "Does One Species of Legume Bacteria Produce an Inhibitory Effect on Another Species within the same Culture?"	241	483
14.	A—Photograph showing 3 rows, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "Alfalfa Bacteria Strain 3DOa1," bottom row headed "Alfalfa Bacteria Strain 3DOa1 Plus 5 Strains Red Clover Bacteria"	241	488
14.	B—Photograph showing 3 row, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "Alfalfa Bacteria Strain 3DOa7," bottom row headed "Alfalfa Bacteria Strain 3DOa7 Plus 5 Strains Red Clover Bacteria"	241	490
14.	C—Photograph showing 3 rows, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "Alfalfa Bacteria Strain 3DOa10," bottom row headed "Alfalfa Bacteria Strain 3DOa10 Plus 5 Strains Red Clover Bacteria"	241	492
14.	D—Photograph showing 3 rows, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "Alfalfa Bacteria Strain 3DOa12, bottom row headed "Alfalfa Bacteria Strain 3DOa12 Plus 5 Strains Red Clover Bacteria"	241	494

NO.		Introduced in Evidence at page	Reproduced at page
14.	E—Photograph showing 3 rows, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "Alfalfa Bacteria Strain 3DOa15," bottom row headed "Alfalfa Bacteria Strain 3DOa15 Plus 5 Strains Red Clover Bacteria"	241	496
14.	F—Photograph showing 3 rows, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "5 Strains Alfalfa Bacteria," bottom row headed "5 Strains Alfalfa Bacteria Plus 5 Strains Red Clover Bacteria".	241	498
15.	A—Two sheets entitled "Experiment No. 1—Crimson Clover, Sept. 22 to Jan. 7, 1938 and Crimson Clover-Trifolium incarnatum, Oct. 19, 1939 to Jan. 20, 1940"	241	500
15.	B—Two sheets entitled "Red Clover Trifolium pratense, Oct. 18, 1939 to Jan. 15, 1940, and Experiment No. 1—Red Clover, Sept. 21 to Dec. 14, 1937".	241	501
15.	C—Two sheets entitled Table 3: "Nitrogen Fixation by Twenty Strains of R. Meliloti on Alfalfa Burr Clover and Sweet Clover, Oct. 15 to Dec. 10, 1938, and Table 3"	241	503
15.	D—Two sheets entitled Table 5: "Nitrogen Fixation by Twenty Strains of R. Meliloti on Alfalfa, Burr Clover and Fenugreek, Feb. 10 to April 17, 1939, and Table 5"	241	505
16.	Document entitled Bulletin No. 115, Delaware College Agricultural Experiment Station; "A Preliminary Report on Muck Humus as a Fertilizer and Carrier of Beneficial Soil Bacteria" by Manns and Coheen, dated December 1916	249	508
17.	Booklet entitled "The Alphano Book," published by Alphano Humus Co., New York City	256	564

NO.		Introduced in Evidence at page	Reproduced at page
18.	Bottle containing sample Humus used during experiments of Thomas F. Manns, in connection with Alphano product composites in research work previous to date of publication of Bulletin No. 115 (Deft's Exhibit No. 16)	257	
19.	Bulletin 377 of January 1923, entitled "Results of Seed and Legume Inoculant Inspection for 1922," of the New Jersey Agricultural Experiment Station, Department of Seed Analysis (Portion of)	259	620
20.	Book of Patents (See List of Patents)	259	
21.	Document entitled "Circular 703, Department of Agriculture"	290	628
22.	Pamphlet entitled "Nitrogen from the Air Converted Into Food for Plants by Ferguson's Nitrogen Bacteria"	294	636
23.	Article entitled "The Effects of Non-beneficial Nodule Bacteria on Austrian Winter Pea," by Leonard and Dodson	295	644
24.	Article entitled "Somes Tests with Soilgro," by Leonard	295	647
25.	A—Letter May 22, 1945, Lockhead to Hofer	303	655
25.	B—Letter June 7, 1945, Conn to Hofer	303	656
25.	C—Letter June 8, 1945, Reid to Hofer	303	657
25.	D—Letter May 29, 1945, Albrecht to Hofer	303	658
25.	E—Letter May 26, 1945, Sears to Hofer	303	659
25.	F—Letter May 21, 1945, Waksman to Hofer	303	660
25.	G—Letter May 23, 1945, Vandecaveye to Hofer	303	661
25.	H—Letter May 23, 1945, Hansen to Hofer	303	662
26.	Photograph showing rows of pots containing plants, the front row bearing the following numbers on individual pots: 3, 4, 2, 0, 1-5, 5, 1, 5, 4, 1-5, 0, 3, 2 and 1	306	664

		Introduced in Evidence at page	Reproduced at page
27.	Photograph showing pots with plants, the following numbers appearing in front of the pots: 1, 1-5, 0, 3 and 2....	306	666
28.	Photograph showing plants in pots...	306	668
29.	Table bearing the heading: Clover Plants—Weights Expressed in grams; and with columns a, b, c, d, e, f, g and h on the left-hand side of the table; and the columns designated as Total, Average, % N, Total N% 8 Pots, and Total on the right-hand side of the table....	309	670
30	Report headed "Comparison of Types of Culture Based Upon Tests made in New York State.....	313	672
31.	Report headed "Yield of Lima Beans from Two Types of Inoculants".....	317	673
32.	Agricultural Bulletin 292 of November, 1934, of Department of Agriculture and Markets of State of New York entitled: "Report of Analysis of Samples of Seed Collected in New York State July 1, 1933 to June 30, 1944. Also report on Legume Inoculant Tests Made in 1934" (Portion of).....	319	674
33.	Article designated as Circular No. 137 (Revised), New York State Agricultural Experiment Station, Geneva, N. Y., "Soil Inoculant Service," by Conn and Hofer, dated January 1, 1934	321	680
34.	File Wrapper of Patent No. 2,200,532.	336	684
35.	Page 114 of book entitled "Root Nodule Bacteria and Leguminous Plants" by Fred, Baldwin and McCoy.....	337	740
36.	Page 136 of book entitled "Root Nodule Bacteria and Leguminous Plants" by Fred, Baldwin and McCoy.....	337	742

PAGE

Memorandum of Holdings, filed Sept. 27, 1945..... 744
Findings of Fact, etc., filed Oct. 10, 1945..... 745
Conclusions of Law..... 752
Judgment entered Oct. 10, 1945..... 754
Notice of Appeal by Kalo, filed Jan. 2, 1946 755
Statement of Points..... 756
Bond for Costs..... 757
Notice of Appeal by Funk, filed Jan. 8, 1946..... 759
Statement of Points..... 760
Cost Bond 764
Stipulation extending time to file Transcript..... 765
Stipulation re: Transcript of Testimony..... 767
Stipulated Designation of Record..... 768
Clerk's Certificate 810

UNITED STATES LETTERS PATENT.

No. 2,200,532—V. S. Bond, May 14, 1940..... 770
No. 865,965—G. H. Earp-Thomas, Sept. 10, 1907.... 780
No. 1,099,121—G. H. Earp-Thomas, June 2, 1914..... 786
No. 1,106,275—W. B. Bottomley, Aug. 4, 1914..... 790
No. 1,252,332—G. H. Earp-Thomas, Jan. 1, 1918..... 792
No. 1,309,723—G. H. Earp-Thomas, July 15, 1919.... 798
No. 1,320,701—Thomas F. Manns, Nov. 4, 1919..... 804

1 Pleas in the District Court of the United States of America within and for the Southern Division of the Southern District of Illinois, held at the City of Quincy in said Division and District before the Honorable J. Leroy Adair, Judge of said Court, on Monday, the 5th day of March in the year of our Lord One Thousand Nine Hundred and Forty-Five and of the Independence of the United States of America, the One Hundred Seventieth year.

Present: J. Leroy Adair, District Judge
Robert Grant, United States Marshal
Howard L. Doyle, United States Attorney
G. W. Schwaner, Clerk

Attest:

G. W. Schwaner, Clerk.

2 IN THE DISTRICT COURT OF THE UNITED STATES,
For the Southern District of Illinois,
Southern Division.

KALO INOCULANT COMPANY,
a corporation,
Plaintiff,
vs.
FUNK BROTHERS SEED COMPANY,
a corporation,
Defendant.
} Civil Action No. Q-62.

Be it remembered that heretofore to-wit: on the 10th day of December, in the Year of our Lord One Thousand Nine Hundred and Forty-three, that being one of the days of the September A. D. 1943 Term of the District Court of the United States for the Southern Division of the Southern District of Illinois at Quincy, there was filed in the office of the Clerk of said Court a certain Complaint for Infringement of United States Letters Patent which said Complaint was and is in the words and figures following, to-wit:

3 IN THE DISTRICT COURT OF THE UNITED STATES,
Southern District of Illinois,
Southern Division.

KALO INOCULANT COMPANY,
a corporation,
Plaintiff,
vs.
FUNK BROTHERS SEED COMPANY,
a corporation,
Defendant.
} Civil Action No. Q-62.

COMPLAINT FOR INFRINGEMENT OF UNITED STATES LETTERS PATENT NO. 2,200,532.

EQUITABLE RELIEF DEMANDED.

I.

(a) Plaintiff is a corporation incorporated under the laws of the State of Illinois, and is a citizen of that

State, having its principal place of business at Quincy, Illinois.

(b) Defendant is a corporation incorporated under the laws of the State of Illinois, and is a citizen of that State, having its principal place of business at Bloomington, Illinois.

II.

(a) This action arises under the Patent Laws of the United States as hereinafter more fully appears.

(b) The acts of infringement hereinafter complained of were and are being committed within the Southern Judicial District of Illinois, Southern Division, and elsewhere within the United States.

4

III.

(a) On May 14, 1940, Varley Sherman Bond being, within the meaning of the patent statutes in force, the original and first inventor of certain improvements in Bacterial Inoculant or Leguminous Plants, and all of the requirements of the then statutes and rules of the Patent Office having been complied with, United States Letters Patent No. 2,200,532 for said inventions were duly and legally issued to plaintiff as assignee of said Varley Sherman Bond.

(b) Since the issuance thereof plaintiff has been and is now the sole owner of all right, title and interest in and to said letters patent No. 2,200,532 and of all rights of recovery thereunder.

IV.

Defendant has been, subsequent to the date of issuance of the said letters patent No. 2,200,532 and prior to the filing of this Complaint, and still is infringing said letters patent and contributing to the infringement of said letters patent by causing to be made, selling or causing to be sold, and using or causing to be used within the Southern District of Illinois, Southern Division, and elsewhere in the United States, a product known as LEGUME-AID INOCULANT embodying the inventions described and claimed in said letters patent, and will continue to do so unless enjoined by this Court.

V.

The required statutory notice has been placed on all inoculant manufactured and sold by plaintiff or by persons authorized by plaintiff under said letters patent, and plaintiff has given written notice to defendant of his infringement thereof but defendant has refused and neglected to discontinue said infringement.

WHEREFORE, plaintiff demands:

(a) That defendant, his agents, servants and employes be enjoined during the pendency of this action and permanently from directly or indirectly making or causing to be made, selling or causing to be sold, or using or causing to be used, any inoculant made in accordance with and embodying the inventions described and claimed in said letters patent No. 2,200,532, or from infringing upon or violating said letters patent in any way whatsoever.

(b) That defendant be required to pay plaintiff such damages as plaintiff has sustained in consequence of the infringement of said patent and to account and pay over to plaintiff all the profits derived by defendant from his infringement of plaintiff's patent;

(c) That defendant pay to plaintiff the costs of this action; and

(d) That plaintiff have such other and further relief as is just.

KALO INOCULANT COMPANY,
By (signed) M. E. LUSK,
Its President.

Thiess, Olson & Mecklenburger,
J. Bernhard Thiess,
C. L. Marx,
M. Hudson Rathburn,
77 W. Washington Street,
Chicago, Illinois.
Chester A. Groves,
W.C.U. Building,
Quincy, Illinois.
Attorneys for Plaintiff.

6 STATE OF ILLINOIS }
COUNTY OF ADAMS } ss:

M. E. Lusk, being first duly sworn on oath, deposes and says that he is the President of KALO INOCULANT COMPANY, the plaintiff named in the foregoing action; that he has read the foregoing Complaint and has subscribed the same on behalf of said corporation; that the statements and facts therein contained are accurate and true of his own knowledge and to the best of his information and belief. This verification is not made by the plaintiff personally because the said plaintiff is a corporation.

(Signed) M. E. Lusk.

Subscribed and sworn to before me this 10th day of December, A.D., 1943.

(signed) Chester A. Groves,
Notary Public.

My commission expires January 4, 1947.

(SEAL)

Endorsed, Filed,
December 10, 1943
G. W. Schwaner, Clerk.

7 And afterwards, to-wit: on the 26th day of January, A. D. 1944, there was filed in the office of the Clerk of said Court in said cause a certain Answer and Counter-Claim of Defendant which said Answer and Counter-Claim was and is in the words and figures following to-wit:

8 IN THE DISTRICT COURT OF THE UNITED STATES

• • (Civil Action No. Q-62) • •

ANSWER AND COUNTERCLAIM OF DEFENDANT.

I.

Now comes the Defendant in the above entitled cause, Funk Brothers Seed Company, by its attorneys of record, and for Answer to the Bill of Complaint filed herein says that it admits that the Plaintiff is a corporation incorporated under the laws of the State of Illinois and a

citizen of that State, having its principal place of business at Quincy, Illinois, as alleged in subparagraph a of paragraph 1 of the Bill of Complaint filed herein.

It is also admitted that the Defendant is a corporation incorporated under the laws of the State of Illinois and is a citizen of that State having its principal place of business at Bloomington, Illinois, as alleged in subparagraph b of paragraph 1 of said Bill of Complaint.

II.

The Defendant admits that this action arises under the patent laws of the United States but denies that it has committed, is now committing, or intends to commit any act of infringement within the Southern Judicial District of Illinois, Southern Division, or elsewhere within the United States and specifically denies the allegations of subparagraph b of paragraph 2 of the Bill of Complaint.

III.

(a) The Defendant admits that United States Letters Patent No. 2,200,532 were issued by the Commissioner of Patents of the United States to the Plaintiff as assignee of Varley Sherman Bond under date of May 14, 1940, but the Defendant denies that said Letters Patent were duly or legally issued and specifically denies all the other allegations of subparagraph a of paragraph 3 of the Bill of Complaint herein.

(b) The Defendant further admits that the Plaintiff herein is now the sole owner of said Letters Patent No. 2,200,532 but denies that there are any rights of any character under the law conferred by said Letters Patent and particularly denies that there are any rights of recovery under said Letters Patent either in the Plaintiff or anyone else.

IV.

The defendant denies that it has committed at any time or is now committing any act of infringement as to said Letters Patent No. 2,200,532 or contributed to the infringement of said Letters Patent in any way within the Southern District of Illinois, Southern Division or

elsewhere in the United States and specifically denies all the allegations of paragraph 4 of the Bill of Complaint herein.

V.

The Defendant having no knowledge of the placing of the required statutory notice on all inoculants manufactured and sold by the Plaintiff as alleged in para-
11 graph 5 of the Bill of Complaint herein other than as contained in said Bill of Complaint, upon information and belief denies the allegations of said paragraph 5 of said Bill of Complaint as to said placing of notice upon the products manufactured by the Plaintiff and calls upon the Plaintiff to prove the same. The Defendant admits, however, that the Plaintiff has served a written notice upon it claiming an alleged act of infringement as to said patent No. 2,200,532 but the Defendant denies that it has committed any act of infringement as to said Letters Patent.

VI.

The Defendant denies each and every allegation of the Bill of Complaint filed herein not heretofore specifically denied or admitted and denies that the Plaintiff is entitled to any relief in law or equity against the Defendant.

VII.

Further answering the Defendant avers and shows to the Court that the Bill of Complaint filed herein fails to state any claim against the Defendant upon which relief could be granted either in law or equity.

12 VIII.

Further answering the Defendant is informed and, therefore, avers that the patentee of said patent in suit No. 2,200,532, to-wit, Varley Sherman Bond, was not the sole original or first inventor or discoverer of any material or substantial part of the alleged invention or inventions described or claimed in said Letters Patent but on the contrary that the invention or inventions de-

scribed and claimed in said patent here in suit and every material and substantial part thereof was shown, disclosed, described or patented prior to the alleged invention or inventions or discovery thereof by said Varley Sherman Bond, or more than two years prior to his application for patent therefor in the following patents and publications, to-wit:

Number	Inventor	Date
865,965	Earp-Thomas	Sept. 10, 1907
899,155	Coates	Sept. 22, 1908
982,569	Bottomley	Jan. 24, 1911
1,002,248	Ellis	Sept. 5, 1911
1,099,121	Earp-Thomas	June 2, 1914
1,106,275	Bottomley	Aug. 4, 1914
1,252,332	Earp-Thomas	Jan. 1, 1919
13 1,289,565	Snelling	Dec. 31, 1918
1,309,723	Earp-Thomas	July 15, 1919
Re.14,686	Earp-Thomas	July 15, 1919
1,320,701	Manns	Nov. 4, 1919
1,355,732	Bottomley	Oct. 10, 1920
1,442,239	Stoltz	Jan. 16, 1923
1,618,461	Matchette	Feb. 22, 1927
1,938,647	Earp-Thomas	Dec. 12, 1933
2,098,918	Henrickson	Nov. 9, 1937

PUBLICATIONS.

"Bacteriology" by Buchanan, published by MacMillan Company, New York City, 1938, pages 120 to 123 inclusive.

"Root Nodule Bacteria and Leguminous Plants" by Edwin Broun Fred, Ira Lawrence Baldwin and Elizabeth McCoy, published by the University of Wisconsin, in 1932, pages 25, 37, 44, 45, 114, 135, 136, 244 and 245 inclusive thereof.

"Laboratory Manual of General Microbiology" by Fred and Waksman, published by McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York City, 1928, pages 16 and 33 thereof.

14 "The Alphano Book", published by The Alphano Humus Company, Whitehall Building, 17 Battery Place, New York City, in 1916 and particularly pages 20 and 21 thereof.

Booklet published and distributed by The Alphano Humus Company of Whitehall Building, 17 Battery Place, New York City, in 1916 in connection with a product of that company advertised under the trade name of "The All-In-One Inoculant".

Booklet entitled "Furguson's Composite Culture of Nitrogen-Fixing Bacteria" published by the Homewood Nitrogen Company, 55 Liberty Street, New York City, May 1, 1913.

Booklet entitled "Nitrogen From The Air Converted Into Food For Plants", published by the Homewood Nitrogen Company, 55 Liberty Street, New York City, June 10, 1914, and also other patents and publications which Defendant is informed and believes are in existence but which it has not yet ascertained and which as soon as known or located, Defendant prays leave to insert herein by proper amendment.

IX.

Further answering Defendant is informed and believes and, therefore, avers that the patent here in suit is wholly invalid and void because the alleged invention or inventions described and claimed in said patent and every material and substantial part thereof had been invented, produced and used and was known to others in this country prior to the alleged invention and discovery thereof by said Varley Sherman Bond or in public use or on sale in the United States for more than two years prior to the application of said Varley Sherman Bond for said patent in suit by the patentees of the various patents set forth in paragraph VIII hereof and by the following named persons, firms or corporations at the following named places, to-wit:

Kalo Inoculant Company, the Plaintiff herein through its officers, agents and employees at Quincy, Illinois.

McQueen Bacteria Company, through its officers, agents and employees at Baltic, Ohio.

The Albert Dickinson Company, through its officers, agents and employees at Chicago, Illinois.

Agricultural Laboratories, Inc., through its officers, agents and employees at Columbus, Ohio.

The University of Wisconsin, through its officers,

agents and employees at Madison, Wisconsin, and by other persons, firms and corporations and at other places at this time unknown to Defendant but which Defendant prays leave to insert herein by suitable amendment as soon as known.

X.

Further answering Defendant is informed and believes and, therefore, avers that the said patent in suit discloses no patentable invention over or in view of the state of the art at and prior to the time application for said patent in suit was filed; that the subject matter of the patent in suit, in view of the then existing prior art, involves and constitutes nothing but unpatentable aggregations and exhausted combinations of parts, elements, steps or details and that such subject matter did not require any exercise of invention and differs from the prior art, if any difference exists, in immaterial and unpatentable details not requiring invention under the patent laws of the United States.

XI.

Defendant further answering avers on information and belief that there is no real invention or novelty in the alleged patent in suit and that the alleged invention or improvement set forth in the claims and specifications forming part of said Letters Patent is not the statutory subject of invention and is not any new and useful art within said statutes in such case made and provided and the said alleged method or process or article is not patentable subject matter under said statutes, the alleged invention of the patentee of the patent in suit merely pointing out the way by use of a natural condition of nature's laws and said patentee not inventing any new process, chemical or otherwise, or article, machine or device whereby the force of nature is controlled.

XII.

Further answering Defendant is informed and believes and, therefore, avers that the specifications of the patent here in suit is ambiguous, incomplete and indefinite, and does not describe the manner of using or practicing the

alleged invention claimed to be disclosed in said patent in suit with such adequacy as is required by the statutes in such cases made and provided, or which would enable any person skilled in the art to make and use the alleged invention purported to be disclosed in said patent and, therefore, said patent is wholly invalid and void.

18 XIII.

Further answering Defendant is informed and believes and, therefore, avers that said patent here in suit was unlawfully obtained and issued by the United States Patent Office without due investigation and that an important part of the relevant prior art hereinbefore set forth was overlooked and other parts of said prior art were improperly implied and construed and that representations made in the specifications of said patent in suit are not based upon fact or truth; wherefore, the Commissioner of Patents exceeded his legal authority in granting the aforesaid Letters Patent and that said patent is, therefore, wholly invalid, void and of no effect.

WHEREFORE, Defendant denies that the Plaintiff is entitled to the relief prayed for in the Complaint, or to any relief, and prays to be hence dismissed with its costs in this cause sustained, and for such other and further relief as to the Court may seem just.

COUNTERCLAIM.

And by way of Counterclaim against the Plaintiff, Kalo Inoculant Company, the Defendant, Funk Brothers Seed Company, now says:

19 (1) The defendant avers that the cause of action set forth in this Counterclaim arises under the patent laws of the United States and involves an actual controversy within the meaning of the Declaratory Judgment Act of 1934, Section 274 (d) of the Judicial Code of the United States, 28 U. S. C. A. 400, between the Plaintiff and the Defendant herein both as to the validity of United States Letters Patent No. 2,200,532 sued on herein in the Bill of Complaint of the Plaintiff and as to the infringement by the Defendant of the rights alleged to be possessed by the Plaintiff herein by virtue of the grant of said Letters Patent No. 2,200,532.

(2) The Defendant by way of asking for affirmative relief, avers that said patent in suit No. 2,200,532 is wholly null and void and invalid in law as to all claims thereof for the reasons set forth in the above and foregoing Answer of the Defendant filed herein, which said Answer the Defendant does now adopt and make a part of this its Counterclaim, the same as if set forth herein verbatim, and that the Defendant has not in any way committed or threatened to commit any act of infringement as to said patent in suit No. 2,200,532.

Wherefore, the Defendant prays as follows:

20 (a) For a Declaratory Judgment under the provisions of the Declaratory Judgment Act of 1934, Section 274 (d) of the Judicial Code of the United States, 28 U. S. C. A. 400, decreeing and adjudging said patent in suit No. 2,200,532 both invalid in law as to all its claims and not infringed by the Defendant.

(b) For an injunction enjoining and restraining the Plaintiff from directly or indirectly instituting, bringing or maintaining any further litigation against this Defendant or its customers under said patent in suit No. 2,200,532.

(c) That the Defendant have judgment against the Plaintiff for its costs herein and for such other and further relief in the premises as to the Court may seem meet and just and to which the Defendant may be entitled.

FUNK BROTHERS SEED COMPANY,
By (Sgd) J. R. Holbert,
Vice Pres. & Genl. Mgr.

STATE OF ILLINOIS }
COUNTY OF McLEAN } ss:

J. R. Holbert, being first duly sworn on oath, deposes and says that he is the Vice Pres. & Genl. Mgr. of FUNK BROTHERS SEED COMPANY, and has read the foregoing
21 Answer and Counterclaim and has subscribed the same on behalf of said Corporation; that the statements and facts therein contained are accurate and true of his own knowledge to the best of his information and belief. This verification is not made by the Defendant personally because the said Defendant is a corporation.

(Signed) J. R. Holbert.

Subscribed and sworn to before me this the 22nd day of January, A. D. 1944.

(Sgd) Elias W. Rolley,
Notary Public.

(Seal)

Toulmin & Toulmin) Address 308 W. First St.
Rowan A. Greer) Dayton, Ohio
Harold W. Lewis Address Stern Bldg., Quincy, Ill.
Attorneys for Defendant
and Cross-Complainant.
Endorsed, Filed,
January 26, 1944,
G. W. Schwaner, Clerk.

22 And afterwards, to-wit: on the 14th day of February, 1944, there was filed in the office of the Clerk of said Court in said cause a certain Plaintiff's Reply to Counterclaim of Defendant which said Plaintiff's Reply to Counterclaim was and is in the words and figures following, to-wit:

23 IN THE DISTRICT COURT OF THE UNITED STATES

* * (Civil Action No. Q-62) * *

PLAINTIFF'S REPLY TO COUNTERCLAIM OF DEFENDANT.

Plaintiff, Kalo Inoculant Company, for its reply to the Counterclaim of Defendant, filed on or about January 26, 1944, says:

I.

Plaintiff denies each and every allegation contained in Paragraphs (1) and (2) of the Counterclaim of Defendant filed herein, denies each and every allegation set forth in the Answer of Defendant filed herein and included by reference in Paragraph (2) of the Counterclaim, and denies that the said Bond patent in suit, No. 2,200,532, is wholly or in any part null or void or invalid in law as to any of the claims thereof for any reason.

II.

Further replying to the Counterclaim of Defendant, plaintiff now adopts and makes a part of this reply to the said Counterclaim, the same as if set forth verbatim in this reply, Paragraphs III, IV, and V of its Complaint herein.

III.

Plaintiff avers that the Counterclaim of Defendant fails to state a claim upon which relief can be granted under the Patent Laws of the United States or under the Declaratory Judgment Act of 1934, Section 274(d) of the Judicial Code of the United States, 28 U.S.C.A. 400; and denies that defendant is entitled to any of the relief sought and prayed for in the said Counterclaim or to any relief whatsoever in this cause; and plaintiff prays that the said Counterclaim be dismissed for want of equity and that costs be assessed and taxed against the defendant.

(signed) Thiess, Olson & Mecklenburger,
Attorneys for Plaintiff.

(signed) J. Bernhard Thiess,
(signed) M. Hudson Rathburn,
77 West Washington Street,
Chicago, Illinois.

(signed) Chester A. Groves,
W. C. U. Building,
Quincy, Illinois.
Of Counsel.

A copy of the foregoing Reply to the Counterclaim of Defendant received this 14th day of February, 1944.
(signed) Harold W. Lewis,
Attorneys for Defendant.

Endorsed, Filed,
February 14, 1944,
G. W. Schwaner, Clerk.

25 And afterwards, to-wit: on the 28th day of October, 1944, there was filed in the office of the Clerk of said Court in said cause a certain Amended Answer of Defendant which said Amended Answer was and is in the words and figures following, to-wit:

26 IN THE DISTRICT COURT OF THE UNITED STATES

(Civil Action No. Q-62)

AMENDED ANSWER OF DEFENDANT.

Now comes Funk Brothers Seed Company, Defendant in the above entitled action, by its attorneys of record and moves the Court for leave to amend the answer of the Defendant heretofore filed herein as follows:

1. By adding to the prior publications as pleaded in Paragraph VIII of the answer heretofore filed herein the following:

Bulletin No. 115 published by the Delaware College Agricultural Experiment Station at Newark, Delaware, dated December, 1916 and entitled "A Preliminary Report on Muck Humus as a Fertilizer and Carrier of Beneficial Soil Bacteria" by Thomas F. Manns and Joseph M. Goheen and particularly pages 6, 25, 27, 38 and 40 and plate illustration No. VII of said publication.

2. By adding to Paragraph IX of the answer heretofore filed herein the following prior users at the end of said paragraph IX of said original answer:

The Kalo Company of Quincy, Illinois, predecessor of the Plaintiff herein, through its officers, agents and employees at Quincy, Illinois.

27 The Earp-Thomas Laboratories, Inc. of Bloomfield, New Jersey, through its officers, agents and employees at Bloomfield, New Jersey.

The Nitrogen Company of Milwaukee, Wisconsin, through its officers, agents and employees at Milwaukee, Wisconsin.

The Earp-Thomas Cultures Corp. of Long Island City, New York, through its officers, agents and employees at Long Island City, New York, in connection with the manufacture and sale of a composite culture under the name of All Crop Farmogerm.

3. By adding the following paragraph numbered XIV

immediately following Paragraph numbered XIII on page 11 of the original answer filed herein as follows:

XIV. The Defendant further answering, avers and shows to the Court that the Bond patent in suit No. 2,200,532 was surreptitiously obtained by the patentee thereof through erroneous and false statements to the effect that it has been previously considered that the nitrogen fixing ability of Rhizobium trifolii in symbiotic relationship with red clover is markedly inhibited if strains of Rhizobium meliloti, Rhizobium japonicum, or other species of Rhizobium were present within the same inoculant and by further falsely representing and stating to the Patent Office that composite cultures for inoculating the seeds of leguminous plants have not generally come into use because of the inhibitory effect that certain strains of certain species of the Rhizobium have on each other and also because no method has been developed whereby a composite culture may be produced wherein a sufficient number of each species of organism in the inoculant is insured. The Defendant is advised and believes that these statements were false and contrary to the fact and were the cause inducing the Patent Office to grant the said Letters Patent in suit, No. 2,200,532 and that as a consequence, the Plaintiff in this action does come into Court with unclean hands and should be repelled and held to be without any remedy from a Court of justice.

FUNK BROTHERS SEED COMPANY,
By (signed) Toulmin & Toulmin,
Attorneys.

(signed) Rowan A. Greer
Solicitors and of Counsel.

Filing of above and foregoing amended answer is consented to without prejudice.
(signed) Thiess, Olson & Mecklenburger,
Attorneys for Plaintiff.

Leave for filing above and foregoing amendment to answer of Defendant granted.
Dated this 28th day of October, 1944.

(signed) J. Leroy Adair,
United States District Judge.

Endorsed, Filed,
October 28, 1944,
G. W. Schwaner, Clerk.

29 And afterwards, to-wit: on the 30th day of April, 1945, the following further proceedings were had in said Court in said Cause and were entered of record as follows:

30 In the District Court of the United States

• • (Civil Action No. Q-62) • •

It is hereby ordered by the Court that said cause be set for trial at Quincy, Illinois, on Monday, May 28, 1945, at 10:00 o'clock A. M.

31 And afterwards, to-wit: on the 14th day of May, 1945, the following further proceedings were had in said Court in said cause and were entered of record to-wit:

32 In the District Court of the United States.

• • (Civil Action No. Q-62) • •

This cause coming on this day to be heard upon the motion of the Plaintiff to vacate the setting of said cause for trial on May 28, 1945, and for a resetting thereof on June 25, 1945, and the court having heard and duly considered the said Motion, it is ordered that the said Motion be and is hereby allowed.

It is, therefore,

Ordered by the Court that the setting of May 28, 1945, be and is hereby vacated and that said cause be and is hereby reset for trial on Monday, June 25, 1945 at 10:00 o'clock A. M. at Quincy, Illinois.

33 And afterwards, to-wit: on the 25th day of June, A. D. 1945, there was filed in the office of the Clerk of said Court in said cause a certain Stipulation which said Stipulation was and is in the words and figures following, to-wit:

34 IN THE DISTRICT COURT OF THE UNITED STATES.

(Civil Action No. Q-62)

STIPULATION.

In order to facilitate the trial of the above entitled cause it is stipulated by the parties as follows:

1. That either party may introduce into evidence uncertified Patent Office printed copies or photostatic copies of Letters Patent of the United States or any foreign country at the trial with the same force and effect as if certified copies of said Letters Patent were offered subject to correction, as to errors, if any, by comparison with said certified copies or originals.

2. That either party may introduce into evidence at the trial photostatic copies of printed articles, books or pamphlets with the same force and effect as if the
35 originals were offered in evidence and that the dates appearing thereon may be regarded as the dates of publication subject to correction as to errors, if any, by comparison with the originals of said documents.

3. That the bill of the stenographer for services rendered in attendance and furnishing the original transcript of the proceedings of the trial to the Court may be paid for, one-half by the Plaintiff and one-half by the Defendant, the total amount of said bill however, to be taxed as part of the taxable cost of the action. Any copy or copies of the proceedings furnished to either party for its own use shall be paid for by the party so ordering such copy or copies and is not to be taxed as cost in the case.

(signed) Thiess, Olson & Mecklenburger,
Attorneys for Plaintiff.

Chicago, Illinois,
June 14, 1945.

(signed) Toulmin & Toulmin,
Attorneys for Defendant.

Dayton, Ohio,
June 7, 1945.

Endorsed, Filed,
June 25, 1945,
G. W. Schwaner, Clerk.

36 And afterwards, to-wit: on the 25th day of June, A. D. 1945, there was filed in the office of the Clerk of said Court in said cause a certain Stipulation which said Stipulation was and is in the words and figures following, to-wit:

37 IN THE DISTRICT COURT OF THE UNITED STATES.

(Civil Action No. Q-62)

STIPULATION.

It is stipulated by the parties that the claims of the Bond Patent in suit No. 2,200,532 which will be relied upon by the Plaintiff at the trial are claims 1, 3, 4, 5, 6, 7, 8, 13 and 14.

(signed) Thiess, Olson & Mecklenburger,
Attorneys for the Plaintiff.

Chicago, Illinois,
June 14, 1945.

(signed) Toulmin & Toulmin,
Attorneys for the Defendant.

Dayton, Ohio,
June 11, 1945.
Endorsed, Filed,
June 25, 1945,
G. W. Schwaner, Clerk.

38 And afterwards, on to-wit: the 4th day of August, A. D. 1945, there was filed in said cause, the Record of Proceedings at the Trial, which said Record of Proceedings was and is in the words and figures, following, to-wit:

61 IN THE DISTRICT COURT OF THE UNITED STATES.

(Civil Action—No. Q-62)

REPORT OF PROCEEDINGS AT TRIAL

in the above-entitled action before Honorable Charles G. Briggle, Judge of said Court, at Quincy, Illinois, commencing on Monday, June 25, 1945.

Appearances:

Messrs. Thiess, Olson & Mecklenburger,
By: J. Bernhard Thiess, Esq.,
M. Hudson Rathburn, Esq. and
Sidney Neuman, Esq.,
77 West Washington Street, Chicago, Illinois,
and
Chester A. Groves, Esq.,
W. C. U. Building, Quincy, Illinois,
on behalf of Plaintiff;

Messrs. Toulmin & Toulmin,
By: Rowan A. Greer, Esq. and D. C. Staley, Esq.,
308 West 1st Street, Dayton 2, Ohio.

Harold W. Lewis, Esq.,
Stern Building, Quincy, Illinois,
and
David Davis, Esq.,
Bloomington, Illinois,
on behalf of Defendant.

62 IN THE DISTRICT COURT OF THE UNITED STATES.

The Court: You may proceed.

Mr. Thiess: If your Honor please, I would like to call Mr. Curie to the stand, of the Agricultural Bacteria Laboratories, Inc., as a hostile witness.

IRVIN HAROLD CURIE, called as a witness herein
63 by the plaintiff, being first duly sworn, was examined and testified as follows:

Examination by Mr. Thiess.

Q. Mr. Curie, will you please give your full name and your present residence?

A. Irvin Harold Curie.

Q. Where do you live?

A. At 110 North Orchard Lane, Columbus, Ohio.

Q. How are you presently employed?

A. By Agricultural Laboratories, Incorporated.

Q. In what capacity?

A. As soil biologist of the firm.

Q. What are your duties as the soil biologist of that firm?

A. It involves superintending the manufacture of the product and carrying on such research as may be desirable to improve the product.

Q. And as soil biologist of this firm, you are in charge, are you, of the manufacture of Legume-Aid that is put out by that company?

A. I am.

Q. I would like to show you a package marked
64 "Legume-Aid" and ask you whether that is the Legume-Aid that is put out by the Agricultural Laboratories, Inc?

A. It is.

Mr. Thiess: I would like to offer this package in evidence as Plaintiff's Exhibit No. 1.

The Court: It may be marked.

(Said package marked "Legume-Aid" was thereupon marked as Plaintiff's Exhibit No. 1, for identification.)

The Court: It may be received.

(Said package was thereupon received in evidence by the Court, as aforesaid, and marked as Plaintiff's Exhibit No. 1.)

Mr. Thiess: Q. Now, in the manufacture of this Legume-Aid, are there any nutrients added to the base in which the bacteria are contained, that is, the humus?

A. There are nutrient materials added.

Q. And to what extent are nutrients added to this humus?

A. To a very slight extent added. The nutrients that are in the solution that goes in with the bacteria con-
65 tains nutrient—that solution contains nutrient material from the agar; that is taken from the agar. There is bound to be some.

Q. Then, the nutrient that you introduce is the nutrient that comes from the agar where the bacteria are multiplied and produced?

A. Yes.

Q. Well, how much nutrient would you say that was?

A. Sufficient to stimulate growth in the humus material.

Q. Well, can you give me how much?

A. I cannot.

Q. You do not know how much you put in it?

A. No.

Q. You have never made a test to ascertain that?

A. No.

Q. So, as far as your company is concerned, they do not know at present how much nutrient you put into this Legume-Aid, in addition to that which is contained in the humus?

A. No, not in terms of chemical analysis.

Q. Now, did I understand you to say that you depend upon the growth of the bacteria in the composite culture?

A. We do not depend upon it. It is there.

66 Q. But you do not know to what extent it is there?

A. We have made such determinations.

Q. Didn't you just tell me that you didn't know how much of that nutrient that you had in it?

A. I beg your pardon. I understood you to ask for the amount of growth that takes place.

Q. Do you know how much of the nutrient that is in there?

A. No.

Q. Now, how is the nutrient solution prepared?

A. By growing the bacteria, as is common knowledge and exposed in the patent, on nutrient agar by methods commonly known.

Q. In other words, you prepare your nutrient solution in the same way as that which is explained in the patent in suit?

A. We do.

Q. And if you got any nutrient in your final Legume-Aid it would be the nutrient that comes out of that solution that is made in that sort of way?

A. That nutrient would be there.

Q. Now, do you have any knowledge of the number of alfalfa and clover bacteria per cubic centimeter in the Legume-Aid solution?

A. It would be easier to state that in the terms of the number that we put in per package, and I do have
67 that knowledge.

Q. What would you say as to that?

A. In the combination package we put in approximately 9 to 10 billion of alfalfa per standard unit, and 14 billion of clover per standard unit.

Mr. Greer: Q. What was it for the clover? I did not get it?

A. About fourteen billion per standard unit.

Mr. Thiess: Q. And that is the amount you put in and which is contained in the solution before it is mixed with the humus?

A. It is.

Q. Now, I believe you said that you tested the amount of growth, is that correct?

A. We have done so.

Q. And what do you find in these tests?

A. We find that the bacteria multiply in the humus after it has been mixed.

Q. To what extent?

A. Approximately 40 times as many, at one time.

Q. How were these tests conducted that you made?
68 A. Those tests were conducted on plates of agar medium, agar jell.

Q. I don't quite follow you. How would you tell about the growth in the Legume-Aid under those circumstances, the growth of the bacteria?

A. It isn't an absolute test, because you are not always certain of one species of bacteria. I can't tell as to the number of alfalfa or clover after the growing period.

Q. Now, "after the growing period," what do you mean by that, Mr. Curie?

A. I mean that after we have mixed our culture with the humus, we allow it to grow for a period of five days before packaging, to encourage this growth in the humus.

Q. Then, after that, you package it and you don't know how much growth there might be after?

A. We do not know the actual number.

Q. And you do not know the actual number during that five-day period, exactly?

A. Not exactly.

The Court: Q. What do you mean by the humus? Is that what you mix it with?

A. That is the black—it is, you might say, a mock soil.

69 The Court: Q. It is the soil?

A. Or the black material underneath.

Q. It is the base, is that right?

A. Yes, it is the base of the mixture.

Q. That might be a number of different things, I suppose, might it not?

A. It may, and is not one material alone.

Q. Well, you use, you say, sort of a black soil?

A. We use that— The humus base includes both the humus and a proportion of charcoal.

Q. I suppose other bases could be used, could they, or could they not?

A. They have been. The humus base has come to be generally used because it has supported the growth of the bacteria in the best nature.

The Court: That is all.

Mr. Thiess: That is all.

Examination by Mr. Greer.

Q. As I understood you, you had conducted tests that showed, after you put the bacteria in the base, there was a further growth for development of the bacteria in that base, is that correct?

70 A. That is true.

Q. But you cannot say accurately as to how much that increase of growth extended?

A. No, no.

The Court: Q. I understood you approximated it at 40 times?

A. Yes, some— There have been tests which indicate that. That figure comes to my mind, that I know that that is what has occurred.

Q. Was that before it was packaged?

A. That is before it was packaged.

Q. Well, will it continue to grow after it is packaged?

A. Other tests that we have run indicate that there is very little change in the number after it is in the closed package.

Mr. Greer: Q. I understood you to say, and I ask you to correct me if I did not hear you accurately, that there was nutrient value, bacteria nutrient value in the solution which contained the bacteria, when you put them in the base?

A. Yes, and also in the base.

Q. That is what I did not understand you to say. Before you put the bacteria in the base, was or was
71 not any bacteria nutrient in the base itself?

A. Yes, there is.

Q. And what was that base composed of?

A. This mixture of peat and charcoal, or peat and charcoal, peat humus.

Q. Your base is one, then, that is composed of peat and charcoal?

A. Yes.

Q. And it does have bacteria nutrient value in it?

A. It does, or they would not multiply in the material.

Q. Now, you have been speaking of this Legume-Aid combination inoculant, have you not?

A. Yes.

Q. How long have you been following that process and producing this?

A. The combination culture has been produced since 1941.

Mr. Greer: Now, may it please Your Honor, so far as this cross-examination is concerned, I don't think I have anything more, but of course I expect to call Mr. Curie as a witness for the defendant as to other matters.

The Court: Will you have him explain just a little more as to what he means by bacteria nutrient?

72 Mr. Greer: Q. Just tell the Court, what do you mean by bacteria nutrient?

A. These bacteria are in effect a miniature plant, a one-cell plant, and accordingly they need, we might say, fertilization.

Q. Wouldn't "food" be the correct term?
A. They need food and they need phosphates.
Q. And you mean by nutrient the food they feed upon?
A. Yes. In other words, this mixture contains food for the bacteria.
Mr. Greer: Does that clear it in Your Honor's mind?
The Court: Yes.
What is the term counsel used this morning in telling the quality that causes them not to conflict with one another?
Mr. Greer: Inhibition.
The Court: What?
Mr. Greer: Inhibition.
The Court: Yes.
Q. Is there something put into the product to cause it to nullify itself with reference to the different kinds of bacteria?
73 A. There is nothing added in any way. It is prepared exactly as a culture for alfalfa.
Q. What is it that causes the inhibition that counsel speak of?
A. Your Honor, I do not know of any such inhibition.
Mr. Greer: You see, that is our position, that there is no inhibition.
The Court: I am getting into something that is not brought out—that is not cross-examination, of course. All right, go ahead.
Mr. Greer: No further cross-examination.
Mr. Thiess: That is all.
74 Mr. Rathburn: I now want to offer in evidence as Plaintiff's Exhibit Number 2 a soft copy of the Bond Patent in suit, No. 2,200,532.
The Court: It may be received.
(Said copy of Bond Patent No. 2,200,532, of May 14, 1940, on Bacterial Inoculant for Leguminous Plants, so offered and received in evidence, was marked as Plaintiff's Exhibit Number 2.)
Mr. Rathburn: The Plaintiff served on the defendant shortly after the case was at issue 40 interrogatories. To most of them we did not get answers that were of any value, so I at this time would like to offer in evidence Plaintiff's Interrogatories 1 to 5 only and Defendant's Answers, and I would like to read them into the record, if it is agreeable.
The Court: You may do so.

Mr. Greer: Are you giving them an exhibit number?

75 Mr. Rathburn: No.

Plaintiff's Interrogatory 1:

"Has defendant at any time sold and/or offered for sale a composite inoculant for alfalfa and clover identified by the trade name LEGUME-AID?"

Defendant's Answer to Interrogatory 1:

"For answer to interrogatory numbered 1, the Defendant states that it does not understand specifically from this interrogatory what is meant by the term 'a compositive inoculant', but states that it has sold a combination inoculant for alfalfa and clover and that is identified by the trade name of LEGUME-AID."

And Plaintiff's Interrogatory 2:

"If the answer to Interrogatory No. 1 is in the affirmative, were any of such sales made within the Southern Division of the Southern Judicial District of Illinois?"

Defendant's Answer to Interrogatory 2:

"For answer to interrogatory numbered 2, the Defendant states that the sales referred to in answer to interrogatory numbered 1 were 'made within the

76 Southern Division of the Southern Judicial District of the State of Illinois.'"

Plaintiff's Interrogatory 3:

"If the answer to Interrogatory No. 1 is in the affirmative, were any such sales made subsequent to May 14, 1940, and prior to the filing of the Complaint herein?"

Defendant's Answer to Interrogatory 3:

"For answer to interrogatory numbered 3, the Defendant states that the sales referred to in the answers to interrogatories numbered 1 and 2 were made subsequent to May 14, 1940 and prior to the filing of the complaint herein."

Plaintiff's Interrogatory 4:

"Was the composite LEGUME-AID specified in Interrogatory No. 1 obtained by defendant from Agricultural Laboratories, Inc., of Columbus, Ohio?"

Defendant's Answer to Interrogatory 4:

"For answer to interrogatory numbered 4, the defendant states that the combination inoculant for
77 alfalfa and clover referred to in the 'answer to interrogatory numbered 1 was obtained by the Defendant from Agricultural Laboratories, Inc. of Columbus, Ohio'."

Plaintiff's Interrogatory 5:

"If the answer to Interrogatory No. 4 is in the affirmative, has Agricultural Laboratories, Inc. assumed, and is Agricultural Laboratories, Inc. exercising control and direction of the defense to this action?"

Defendant's Answer to Interrogatory 5:

"The answer to interrogatory numbered 5 is 'yes'."

That is the end of the Interrogatories, Your Honor. We also served on defendant approximately 80, I think it was, Requests for Admissions. We got satisfactory answers to only some of them, and I would like to read into the record those requests and answers. In many cases, the defendant answered the Request and then coupled with it a self-serving statement or qualification. I only propose to read the part that is in answer, because the self-serving statement
78 has no place in the record.

Mr. Greer: Well now, on that, Your Honor, we object to just a partial introduction of the Requests for Admissions. If he is going to introduce any of it, I think the whole of the requests and the responses to them should be in the record.

The Court: I will pass on that. I would have to pass on that piecemeal as they are read. It is entirely conceivable that the defendant might add something to it that wouldn't be admissible at all.

Mr. Rathburn: We are offering these only as admissions, Your Honor.

The Court: Yes.

Mr. Rathburn: And if the Court prefers, I will read the whole answer and then move to strike the last part.

The Court: Yes. That will give me what it is, anyway.

Mr. Rathburn: Yes.

The first Request for Admission under Rule 36:

"Plaintiff, Kalo Inoculant Company, requests defendant, Funk Brothers Seed Company, to admit,
79 for purposes of this action only and subject to all objections to admissibility which may be interposed at the trial, that each of the following statements is true:

Legume inoculants are living cultures of root nodule bacteria which in ordinary use are applied to legume seeds prior to planting."

Defendant's Response to Request 1:

"The Defendant admits that legume inoculants are living cultures of root nodule bacteria which are applied sometimes to legume seeds prior to planting but this admission is qualified by the statement that the legume inoculants may be applied to the soil as well as to the seeds."

81 Request No. 2:

"Root nodule bacteria, applied to the seeds of leguminous plants prior to planting, infect the roots of the plants and cause nodules to be formed on the roots."

Defendant's Response to Request No. 2:

"Broadly speaking, the answer to request No. 2 is 'Yes' though the word 'invade' is strictly speaking more accurate than the word 'infect'."

82 Mr. Rathburn: Request No. 3:

"Leguminous plants, when infected by root nodule bacteria effective with respect to nitrogen fixation, are capable of assimilating or fixing nitrogen taken from the air."

Defendant's Response:

"Leguminous plants when 'infected' or invaded by root nodule bacteria effective with respect to nitro-

gen fixation, are capable of assimilating or fixing nitrogen taken from the air."

83 Mr. Rathburn: Request No. 4:

"Unless root nodules are formed on the roots, leguminous plants are unable to use or fix nitrogen from the air."

The Court: Used or fixed?

Mr. Rathburn: Used or fixed.

The Court: Are those words synonymous?

84 Mr. Rathburn: They are synonymous.

The Court: All right.

Mr. Rathburn: Defendant's Response 4:

"It is a generally accepted fact that unless root nodules are formed on the roots leguminous plants are unable to use or fix nitrogen from the air or soil."

Request No. 5:

"Root nodule bacteria capable of infecting the roots of leguminous plants are of the genus known as Rhizobium."

Defendant's Response 5:

"Root nodule bacteria capable of invading or 'infecting' the roots of leguminous plants have recently been known as Rhizobium but were formerly called or known as bacillus radicicola."

Request No. 6:

"When plowed under, inoculated legume plants, which have assimilated nitrogen taken from the air,

85 enrich the soil by increasing its nitrogen content."

Defendant's Response 6:

"When plowed under inoculated legume plants which have assimilated nitrogen taken from the air enrich the soil by increasing its nitrogen content when the soil is properly supplied with mineral elements."

Mr. Rathburn: Request No. 18:

"Accepted scientific opinion is that the size and number of the root nodules formed on the roots of a leguminous plant do not measure the quantity of nitrogen fixed from the air."

Defendant's Response to Request No. 18:

"The size and number of the root nodules formed
86 on the roots of leguminous plants cannot be considered a measure of the amount of nitrogen fixed. The extent or degree of nodulation may give some indication of nitrogen fixation but is not a quantitative value."

Request No. 19:

"The efficiency of any strain of root nodule bacteria is measured by the extent of its benefit to the host plant."

Response No. 19:

"The efficiency of any strain of root nodule bacteria is measured by the extent of its benefit to the host plant."

87 Mr. Rathburn: Request No. 20:

"The extent of benefit to a host plant caused by a strain of root nodule bacteria, is evidenced by the
88 amount of nitrogen fixed in the plant."

Response No. 20:

"The correct statement should be that the extent of benefit to a host plant caused by a strain of root nodule bacteria is evidenced by the amount of atmospheric nitrogen fixed in the plant."

"The total amount of nitrogen fixation may to some extent come about from the nitrogen absorbed from the soil by the plant in addition to the amount caused by the strain of root nodule bacteria."

89 Request Number 21: The amount of nitrogen fixed in plants inoculated by certain bacteria can be determined only by chemical analysis of the plants.

Response Number 21: The amount of nitrogen fixed in plants inoculated by certain bacteria can be determined only by chemical analysis of the plants.

Mr. Rathburn: Request Number 22: Cultures of a single species of root nodule bacteria for field legumes, which cultures are classified as excellent in regard to their nitrogen fixing ability, are manufactured in several commercial laboratories and distributed through regular seed trade channels at a reasonable cost to the customer.

Response Number 22: The statement as to Request
90 No. 22 is correct.

Mr. Rathburn: Request Number 24: Prior to August 24, 1938, the filing date of the application for the Bond patent, No. 2,200,532, in suit, defendant did not offer for sale and Agricultural Laboratories, Inc., of Columbus, Ohio, did not manufacture and sell any inoculant for either the red clover or the alfalfa cross-inoculation groups, other than single culture inoculants, i.e., inoculants containing strains of root nodule bacteria of only one species.

Response Number 24: Prior to August 24, 1938 the Agricultural Laboratories, Inc. of Columbus, Ohio did not manufacture and sell and the Defendant did not
91 offer for sale any inoculant for either the red clover or the alfalfa so called cross-inoculation groups other than single culture inoculants i.e., inoculants containing root nodule bacteria for more than one of these plants.

Request Number 25: The Legume-Aid Inoculant, Combination for Alfalfa and Clover Groups, obtained from Agricultural Laboratories, Inc., and sold by defendant, contains two species of root nodule bacteria.

Response to Number 25: For response to request No. 25 the Defendant states that the Legume-Aid inoculant combination for alfalfa and clover groups obtained from the Agricultural Laboratories, Inc. and sold by the Defendant contains two strains of root nodule bacteria.

Request Number 26: One of the species of root nodule bacteria contained in the Legume-Aid Inoculant, Combination for Alfalfa and Clover Groups, sold by defendant is the species known as Rhizobium trifolii.

Response Number 26: One of the strains or varieties of root nodule bacteria contained in the Legume-Aid inoculant sold by the Defendant is that which some scientists describe and call Rhizobium trifolii.

92 Mr. Rathburn: Request No. 27: One of the species of root nodule bacteria contained in the Legume-Aid Inoculant, Combination for Alfalfa and Clover Groups, sold by defendant is the species known as Rhizobium meliloti.

Response to Number 27: One of the strains or varieties of root nodule bacteria contained in the Legume-Aid inoculant sold by the Defendant is that which some scientists designate and call Rhizobium meliloti.

Request No. 28: The root nodule bacteria in the Legume-Aid Inoculant, Combination for Alfalfa and Clover Groups, sold by defendant are contained in a base including humus.

Response to Number 28: The root nodule bacteria in the Legume-Aid inoculant sold by the Defendant are contained in a base including humus.

Request Number 29: The root nodule bacteria in the Legume-Aid Inoculant, Combination for Alfalfa and Clover Groups, sold by defendant are contained in a moist powder base.

Response to Number 29: The root nodule bacteria
93 in the Legume-Aid inoculants sold by the Defendant are contained in a moist powder base.

Request Number 34: The Legume-Aid Inoculant, Combination for Alfalfa and Clover Groups, sold by defendant is as efficient in respect to its ability to fix nitrogen in red or crimson or mammoth clover plants as a single culture containing the same strains of Rhizobium trifolii as are contained in the said combination Legume-Aid.

Response to Number 34: The Legume-Aid inoculant sold by Defendant is as efficient in respect to its ability to fix nitrogen in red or crimson or mammoth clover plants as a single culture containing the same strains of clover bacteria (Rhizobium trifolii) as are contained in the Legume-Aid for alfalfa and clover.

95 Request Number 35: The Legume-Aid Inoculant, Combination for Alfalfa and Clover Groups, sold by defendant is as efficient with respect to its ability to fix nitrogen in alfalfa or sweet clover plants as a single culture containing the same strains of Rhizobium meliloti as are contained in said combination Legume-Aid.

Response to Number 35: The Legume-Aid inocu-
96 lant sold by Defendant is as efficient in respect to its ability to fix nitrogen in alfalfa or sweet clover plants as a single culture containing the same strains of alfalfa bacteria (Rhizobium meliloti) as are contained in the Legume-Aid for alfalfa and clover groups.

VARLEY SHERMAN BOND called as a witness hereby by the plaintiff, being first duly sworn, was examined and testified as follows:

Direct Examination by Mr. Thiess.

Q. Will you please state your full name, your residence, and present occupation?

A. My name is Varley Sherman Bond; 1628 York Street, Quincy, Illinois.

Q. And your present occupation?

97 A. My present occupation is Chief Bacteriologist of the Kalo Inoculant Company, Quincy, Illinois.

Q. Now, will you please state, Mr. Bond, the training and experience that you have had which would qualify you as an expert in the bacteriological line, particularly with respect to bacteria for use as cultures for plants?

A. I received my Bachelor of Science degree from the University of Wisconsin, and my Master of Science degree from the same institution. The Master of Science degree was granted in the Department of Agriculture; well, it was from the Department of Agricultural Bacteriology.

In addition to that, I spent 2 1/2 years as Research Assistant in the laboratory at the University of Wisconsin, investigating the biological chemistry of this same particular nitrogen fixation problem.

After leaving school I have had nine years' experience in the commercial field of legume inoculants with the Kalo Inoculant Company, here in Quincy.

Q. Now in this graduate work you used the broad expression there,—did you, for my benefit and for the benefit of his Honor,—did you do any work particularly in the field of legume bacteria?

A. All of the work was devoted to this particular
98 field of legume bacteria and its relation to the legume plants.

Q. (By Mr. Thiess) Under whose direction was that?

A. That was directly under Dr. P. W. Wilson and indirectly under Dr. Baldwin and Dr. Fred, both of whom are well-recognized authorities in this field.

Q. Dr. Fred; is that the man that was president of the University of Wisconsin later on?

A. Dr. Fred is now president of the University of Wisconsin.

Q. Now, what generally was the character of work that you did in the laboratory of the Kalo Inoculant Company?

A. I was in charge of the commercial production of the legume cultures and also was in charge of research to improve and maintain the quality of the product.

Q. And you are the Varley Sherman Bond who is the patentee named in the U.S. Patent 2,200,532, here in suit?

A. I am.

Q. Now, Mr. Bond, will you please tell us what leguminous plants are?

99 A. Leguminous plants are plants that commonly bear their seeds in pods such as peas or beans, alfalfa, clover; and there are several others in this family of plants.

Q. Are there any other features that are characteristic to the leguminous plants besides this podding feature, as you call it?

A. Legume plants are also characterized by their ability to fix atmospheric nitrogen, when nodules are present on their roots.

Q. Now, will you please explain what these nodules are that are fixed to the roots, and have you got a plant here that you want to show us?

A. Yes.

The Court: You are saying nodules that are fixed to the roots?

The Witness: Nodules that are on the roots; that are part of the root.

The Court: You used the term "fixed" in an entirely different way.

The Witness: Did I say "fix"?

The Court: You said something about fixing the nitrogen.

The Witness: Yes; by "fix" we mean the nitrogen
100 of air which is unavailable to plants as such; it is very inert. It is a gas. 80% of the air in the room is nitrogen, but somehow or other these bacteria in the nodules, in combination with the plant, are able to convert that nitrogen so that the plant may use it.

It is the same thing as applying a nitrogen fertilizer, such as nitrates, to the plant.

The Court: That is what you mean when you use the term "fix"?

The Witness: By "fix" we mean the taking out of the

air of atmospheric nitrogen and putting it in a form that the plant can use it.

The Court: The plant's ability to do that depends on these nodules on the roots?

The Witness: If the nodules are not present on the roots no fixation takes place.

The Court: All right.

Q. (By Mr. Thiess) Now, will you just explain those nodules to his Honor and illustrate what you have in those two pots.

A. These pots were just taken from an experiment we had in the greenhouse. This pot (indicating) was inoculated with strains of soybean bacteria and you can
101 see the nodules that formed on these roots, these little lumps or nodes which cover the root tissues (indicating).

The majority of these are near the top or so-called tap root. And the difference between this group of plants and this group here (indicating), in which no nodules are present, or, if there are, there may be a few little ones scattered around, coming as a result of contamination,—but the difference between these two plants is solely due to bacteria on the roots.

These had inoculation added to them (indicating one pot) and these did not (indicating the other pot), and the difference between the two pots is solely due to the bacteria.

The Court: The same length of growth, etc.?

The Witness: They were started at the same time and grown under identical conditions.

Q. (By Mr. Thiess) And grown in sterile sand, are they not?

A. Yes.

The Court: Grown under the same conditions so that they would be comparable?

The Witness: That is right; to measure what effect these bacteria have. We grow the plants just as
102 closely as we can, under identical conditions, and the difference between the plants is measured specifically by chemical analysis and treatment, which we will later explain.

Q. (By Mr. Thiess) Now, is there any well-known scientific information with respect to how these nodules are formed? Is it due to an infection of the roots?

A. Yes, the bacteria from the cultures enter the roots

of the plant and cause a swelling or enlargement of the root tissues and it results in the nodules that we just demonstrated, on the roots of these plants.

Q. And are nodules of this character exclusive to leguminous plants?

A. Nodules of this character are exclusive to leguminous plants.

Q. Now, how do other plants, such as grains and grasses, get the necessary nitrogen for their development?

A. Grains and grasses can only obtain nitrogen for their development from the mineral forms of nitrogen contained in the soil or possibly organic forms of nitrogen, too, that are in the soil.

They are the only sources of nitrogen to the non-leguminous plants.

The Court: I want to be clear about that. They
103 get their ability to absorb nitrogen from what is in the soil—

The Witness: No; all plants have a certain percentage of nitrogen in them, contained as proteins, whether it is corn, wheat, soybeans, alfalfa, or whatever plants you may select.

The protein in the plant contains nitrogen as a chemical element and that chemical element had to come from somewhere. In the case of corn and the non-leguminous plants, and wheat, it comes from the nitrogen already contained in the soil,—the fixed nitrogen in the soil.

Legumes can also take fixed nitrogen from the soil but with the presence of legume bacteria on the roots in nodules, they can also take atmospheric nitrogen out of the air. It is a very unusual quality of leguminous plants.

Q. (By Mr. Thiess) Now, to what extent are these nodules of these leguminous plants beneficial to the plant itself and to the soil?

A. The nodules benefit the plant in this way: The combination of bacteria and the plant, and the nodule somehow or other is able to fix this atmospheric nitrogen, and it results in an increased yield to the plant and it also increases the protein content of the plant.

104 If this plant is, in turn, plowed under and allowed to decompose in the soil it has the same effect as though you had added mineral fertilizers to the soil,—nitrogen fertilizers.

Q. (By Mr. Thiess) What do you mean when you say you inoculate a legume?

A. An inoculated legume is one the roots of which are infected with a legume bacteria, and the evidence of which is shown in the form of nodules.

Q. And where do these bacteria come from?

A. The bacteria are present in the soil to a certain extent. Some soils are well-established with these legume bacteria and others do not have them present at all.

Q. And why is it advantageous to inoculate seeds of legume plants with this bacteria if they are found in the soil?

A. Well, if the bacteria are already in the soil, the odds are that they are of an inefficient strain, or they may not be of the correct cross-inoculation culture.

For example, a soil containing soybean organisms would in no way benefit clover plants, if they have been planted in that soil.

105 Q. To what extent, if any, are inoculated legume crops advantageous from the standpoint of crop rotation?

A. It is a well-known precept of agriculture, that the rotation of legume crops with non-leguminous, benefits the non-leguminous crop as well as the leguminous crop.

If the leguminous crop is plowed into the soil, the nitrogen fixed from the air is available to the succeeding crop and therefore increases its yield.

Q. To what extent are the bacteria of the genus Rhizobium found in the soil?

A. Well, the bacteria are found in some soils and are not found in others. They are not universally present in the soil.

The Court: You say if the leguminous plants are plowed up and rotated by the non-leguminous, it would be advantageous to the non-leguminous also?

The Witness: That is true.

The Court: But these bacteria that you infect the leguminous plants with, have no effect on the non-leguminous?

The Witness: They have no effect. The benefit is due to the addition of the nitrogen to the soil. It is equivalent to adding nitrogen fertilizer to the soil. The soil 106 is enriched with respect to its nitrogen content.

The Court: It is not the effect on the plant itself but what the plant has done to the soil?

The Witness: If the plant is plowed under and decom-

poses. If the crop is removed from the soil, the benefit to the soil is very small, if any.

However, at the same time the soil would be indirectly benefited, because it has not withdrawn nitrogen out of the soil. It has left whatever is in there so that the following crop is going to have more nitrogen.

Q. (By Mr. Thiess) What is meant by the term thorough inoculation as used in this art?

A. Thorough inoculation is inoculation of the roots of leguminous plants in such a manner that an ample supply of nodules are formed on these roots.

Q. And in the event that the bacterial content of the soil is not sufficient to form the desired number of nodules, what has been the practice with regard to providing the proper number of bacteria for this purpose?

A. There is no way to tell how many of the legume organisms may be in the soil, and it is now a common practice to apply cultures of legume bacteria to the seeds prior to planting, in order to insure each seed,—each
107 root that develops from these seeds,—in order to insure the bacteria on the roots of these plants, so that the nodules can be formed and the plant can benefit from it.

Q. What do you mean by the term artificial cultures, as used in this art?

A. Artificial cultures are cultures prepared in a laboratory and sold through regular seed trade channels to the farmer who, in turn, applies them to the seeds of his leguminous plants.

Q. Will you now please explain rather fully how these bacteria Rhizobium are divided into species?

A. Well, it is known that the legume—

The Court: Tell me first what the bacteria Rhizobia is; tell me what Rhizobia means.

The Witness: Rhizobia is the plural of the genus terminology that is used in bacteriology. The genus name for this group of legume bacteria is Rhizobium; the plural of Rhizobium is Rhizobia, and clearly referring to the bacteriological classification of root nodule bacteria.

A. (continued) The root nodule organism isolated
108 from one plant, such as clover, normally does not form nodules on plants such as alfalfa and soybeans, peas or beans.

Likewise, the organisms isolated from alfalfa will not form nodules on clover. However, it has been found

that the organisms isolated, say, from red clover will also inoculate crimson clover and mammoth clover and Alsike clover,—that whole group of clover plants which is called a cross-inoculation group because bacteria isolated from the nodules of any one of them will form nodules on any of the others.

Q. (By Mr. Thiess) Now, will you please identify the species of the well-recognized cross-inoculation groups as known in this art?

A. There are six well-known species in the art. Rhizobium trifolii will form nodules again on red clover, crimson clover, Alsike clover, and certain others of the clovers.

Rhizobium meliloti will form nodules on alfalfa as well as white and yellow sweet clovers. Rhizobium phaseoli will form nodules on garden beans. Rhizobium leguminosarum will form nodules on peas; Rhizobium lupini will form nodules on lupins, and Rhizobium japonicum is capable of forming nodules on soybean plants.

109 Those are the principal groups.

Q. Now there are other species of Rhizobium which exist in the soil, are there?

A. There are other groups of organisms which have not been specifically defined, due to the fact that their reciprocal inoculation of different species is not uniform. That is, at times an organism, isolated from other plants, will form nodules on another, but the bacteria from the second plant will not form nodules on the first.

It is a non-reciprocal inoculation. That is the reason that these additional groups have not been assigned a specific terminology, and the reason that we say they are not well-defined.

Q. Well, briefly stated, the six groups are the ones that are really used commercially?

A. The six groups are the ones used most, commercially; outside of this specific terminology there are the cowpeas organism and lespedases and a few others. The principal groups, commercially important to the farmer, and to the commercial inoculant manufacturer, are alfalfa, clover, soybeans,—the six groups.

110 Q. Now, what do you mean in this art when you speak of a pure culture?

A. A pure culture is one that contains a single strain of the organisms; that is, there are no other contaminating bacteria present, or no other bacteria, even of the

legume bacteria, present, other than that one species or one strain of a species.

Q. Now, I would like to have you explain how the pure cultures of the various species are obtained, and in this connection I am going to hand you a drawing which was made under your supervision, and which I will ask the Notary to mark for identification as Plaintiff's Exhibit 3, which you can use in making this explanation.

(Said chart, headed "Source of Stock Strains", was thereupon marked as Plaintiff's Exhibit 3 for identification.)

A. This first chart illustrates the source of stock strains of bacteria that are subsequently used in manufacturing commercial inoculants. Figure 1 is a pic-
111 ture of a clover plant that is taken from the field. On the roots of this plant are found the nodules identified at 2.

Q. Nodules like the ones you show on the growing plants?

A. Nodules like the ones shown on the soy bean plants. The nodule is picked from the plant, a large view of which is shown in 3, and by means of bacteriological isolation, according to technique known to the art, as shown in Box 4, the bacteria are transferred to a jelly slant, illustrated at 5. This slant is a test tube with a cotton stopper at the top and jelly at the base, and on the surface of this jelly the bacteria are grown.

The Witness: That is all right, I think the diagram is clear enough. The bacteria in this test tube are subsequently tested by means of laboratory tests to ascertain whether the culture of bacteria is pure; also by nodulation tests to make sure that these bacteria are from the red clover group. And this is followed by
112 efficiency tests for nitrogen fixation to determine how beneficial this particular stock test tube culture may be when used in a commercial product.

Mr. Thiess: Q. Now, the test tube contains the slant. Can you just go into that a little more fully and state what you have got in that test tube and what happens in that test tube?

A. Well, the test tube—the jelly at the base of the test tube contains food materials on which these bacteria grow.

Q. That is the nutrient we were talking about earlier in this case?

A. That is the nutrient we were talking about, that is correct. And the bacteria are transferred to this tube by standard bacteriological methods, and subsequently the tube is incubated or stored in a slightly elevated temperature for anywhere from two or three days to a week, to permit the bacteria to multiply and grow on the surface of this jelly.

Q. And the bacteria from Box 4, where you say "Bacteriological Isolation", is transferred to the tube manually, or just how do you do that?

A. Well, it is—do you want me to describe the procedure of isolating the organism from a nodulation?

113 Q. I don't believe it is necessary to go into all that.

A. It is transferred by means of a loop. That is a standard piece of apparatus in bacteriological isolation.

Q. And the bacteria that are developed on this slant are a larger number, are they?

A. Yes, a larger number of organisms. It runs into the millions that are developed on a single slant.

Q. Now, will you explain just a little bit more what you mean by laboratory tests for purity?

A. Well, laboratory tests for purity are again standard bacteriological tests, in that slides are made of the bacteria and they are examined under the microscope to see if—it is typical staining reactions, and also if they are of the proper size and shape. In addition to that biochemical tests are run in test tubes to determine whether contaminating organisms are present or not. It is again a standard bacteriological procedure familiar to the art.

Q. And to what extent is this purity essential?

A. Well, frequently in isolating the bacteria from the nodule, 3, contaminating organisms are also intro-

114 duced into the stock test tube slant, and to insure that this is a pure culture of the particular organisms isolated these purity tests are conducted.

Q. Now, will you also give the same explanation as to the nodulation tests which are referred to on the chart? Will you just generally give me an answer to that question?

A. Oh, the nodulation tests are conducted to ascertain that the organisms that are in that test tube will again form nodules on clover plants.

Q. Now, I again refer you to a drawing which was

prepared under your direction and which I will ask to have marked for identification as Plaintiff's Exhibit 4.

(Said chart, headed "Nodulation Test", was thereupon marked as Plaintiff's Exhibit 4 for identification.)

Q. Using this drawing will you explain in detail how your nodulation test is made?

A. Well, in order to test the stock strain diagrammed at 1, to determine whether it contains the proper type of bacteria to form nodules again on clover plants; we use tumblers filled with sterile sand, diagrammed in 2 115 and 3. There are two series of those tumblers run. One of them is called the uninoculated control series and the second series is called the inoculated series. The sterile sand—and tumblers 2 and 3 has sterile sand planted in it—and nitrogen, free nutrient solution, is added. The sand is sterilized and the seed is sterilized to insure the absence of any stray contaminating organisms that may have been in the sand or on the seed. To the sterile sand, and the seeds planted in tumbler 3, the bacterial suspension as diagrammed in Box 5 is added. This bacterial suspension is, in turn, obtained from our stock strain 1 by adding sterile water to it and making a suspension of the bacteria growing on the surface of the jelly slant.

Both series are treated exactly alike except the inoculated series has a bacterial suspension in box 5 added to it.

After approximately three to five weeks growth, at which time clover plants would be approximately two to four inches high—it is diagrammed in 6, or illustrated in Nos. 6 and 7—the plants are removed from the tumblers, the sand is washed from the roots, as diagrammed in Boxes 8 and 9, and the roots of plants 10 and 11 are inspected for the presence of nodules. If no nodules 116 are found on the roots of the plants, Figure 10 of the uninoculated control series, and if nodules are found on the plants, 11 of the inoculated series, that is considered a positive nodulation test. That means that the bacteria in the stock test tube strain 1 were of the species or of the group that will form nodules on these particular plants.

Q. Now, what is the purpose of having the two series of tests, one with the uninoculated series and one with the inoculated series? Just give me that again in a few words.

A. Well, the reason for using the uninoculated control series is to determine whether the nodules that are formed in the inoculated series come only from this stock test tube strain over here. They may have come from the sand, since it may not have been properly sterilized, or they may have come from the seeds, or may even have come—stray bacteria from the air may cause the formation of nodules, and the only way to check to see that the nodules that are on the plants did come from the culture is to run an uninocu-
117 lated control series at the same time. If no nodules are formed there, then the sand is sterile and there were no bacteria drawn from the air, and your seeds are sterile and you are sure again that the nodules formed on these plants came only from the stock test tubes.

Mr. Thiess: Q. If at the close of your test you found that nodules had been formed on control plant 10, what would you consider this as showing?

A. That is just what I explained.

Q. Now, in the diagram, Plaintiff's Exhibit 4, you show three to five weeks' growth between the sterile sand pots and the plants. To what extent are the plants developed in that period of time?

A. Well, normally they will develop two to four inches.

The Court: Q. Are you speaking of the test tube in terms of yield or are you speaking of inoculating the plant?

A. In this particular case the plants are not grown up for a long enough period for the bacteria to take any effect on the yield of the plant. There is another test coming up in which we discuss the efficiency
118 tests, on which the importance of our work is based.

Q. The first few weeks it does not make any difference?

A. In the first few weeks very little difference is observed. After the end of five weeks normally the inoculated series will look greener and the plants may be a little higher, but it is scarcely long enough for any real significant difference to show up.

119 The Court: Q. Does the plant produced by the inoculation, does that necessarily mean that it will produce more and better beans, or whatever the—

A. That is right, that is the fundamental purpose of inoculation, is to increase the yield of the crop to the

farmer, not only in the plant but in the beans and seed as well.

120 Mr. Thiess: Q. Now, you have referred to these efficiency tests on Plaintiff's Exhibit 3 as the last test. And what do you determine by these efficiency tests?

A. The efficiency tests determine the nitrogen fixing ability of these bacteria. Some of the bacteria will form nodules but will not benefit the plant on which they are growing. On the other hand, other organisms, or other strains of the same organism, will produce a maximum yield of the plant.

Q. Then, as I understand you, the nodulation test is no criterion of the amount of nitrogen that the plant might fix?

A. The nodulation test merely indicates the presence of the right type of organisms. It does not indicate how much benefit the plant will obtain from that organism.

121 Q. What have you to say with respect to the comparative ability of the different strains of the same group of root nodule bacteria, to benefit the host plant?

A. The strains have been roughly classified all the way from poor to good strains. A poor strain produces a very slight increase in benefit. A fair strain will produce a little more, and a good strain or excellent strain will produce the maximum amount of benefit to the plant. There is a considerable variation between these strains of bacteria, just as there are in any other biological phenomena. There is a difference in corn seeds. That is, one corn plant will produce twice as much as another. Different strains of different plants and different animals will produce differences in yields. The same thing is true of bacteria.

Q. By strains you mean strains of one particular species?

A. In respect to the nodule bacteria, yes.

Q. When you say there are differences in strains, am I correct in saying that those differences in the strains of bacteria are just the same as there are differences between individuals? No two individuals are alike,

122 is that correct?

A. That is right, some are short and some are tall.

Q. I now wish to hand you another chart which you have made, to explain the efficiency test, and which I

would like to have marked for identification as Plaintiff's Exhibit 5.

(Said chart, headed "Efficiency Test for Nitrogen Fixation", was thereupon marked as Plaintiff's Exhibit 5 for identification.)

Q. Referring to this exhibit, explain rather fully just what this efficiency test is and why it is conducted.

A. Well, this chart illustrates an efficiency test for nitrogen fixation. Going back to our stock strain 1, which was isolated and tested for nodule formation in accordance with the previous charts, we now—after having tested it bacteriologically and for nodule formation, a third test must be made for its efficiency. Sterile sand in half or one gallon pots—these are half gallon
123 pots that we have these soy beans in—is again watered with nitrogen-free nutrient solution and planted with sterile seed as diagrammed in Box 3. However, instead of permitting the plants to grow for just a short period of time, they were permitted to grow for from two to three months, even longer, until mature plants develop in these pots, as diagrammed in 5. The sand is then washed from the roots, as indicated in Box 6, and the plants are subsequently dried as indicated in 7. These dried plants are then weighed as shown in Box 8, and a sample of these dried plants is removed—that is, the dried plants are first ground and a sample is removed to determine the amount of nitrogen that is contained in the dried plants.

This is done by a standard chemical procedure which is called the Kjeldahl nitrogen analysis, as diagrammed in Box 9. The dry weight of the plants as obtained from the measurement in 8 times the percentage nitrogen determined in accordance with the Kjeldahl analysis gives us the total nitrogen that is contained in the inoculated plants.

At the same time and under identical conditions a second series of uninoculated control is also run.
124 These are treated in exactly the same way, except that no bacteria are added to them. This is comparable to the uninoculated series diagrammed in the previous chart on nodulation; that is, it is started in the same manner but again the dry weight of the uninoculated controls is measured and the percentage of nitrogen is measured and the total nitrogen of the uninoculated controls is determined.

Now, the efficiency of stock strain 1 is the amount of nitrogen fixed by that strain, and is equivalent to the total nitrogen of the inoculated series minus the total nitrogen of the uninoculated control series.

Q. Have you finished?

A. Yes.

Q. Now, why do you subtract the total nitrogen control from the total nitrogen inoculated to get your nitrogen fixed, that is, the efficiency?

A. Well, the difference in the nitrogen in the inoculated plants and the nitrogen in the control plants is due to the atmospheric nitrogen fixed from the air by the bacteria which were obtained from this stock test tube 1. Now, there is a small amount of nitrogen in the seeds of the plants, and also possibly in the
125 sand, and this nitrogen is found in the uninoculated control series. The inoculated series likewise have this same nitrogen in them. Therefore, the difference between the control series and the inoculated series gives us the result of the efficiency of these bacteria, tells us how good they are.

Q. Now, what is the general purpose of running one of these efficiency tests?

A. Well, the efficiency test is to determine how good the bacteria—and is diagrammed again here in 1,—how good these bacteria that have been isolated will be in benefiting the crop to which they will be applied, and it is only by means of efficiency tests that we are able to select the highly efficient or good strains of bacteria and use them in commercial culture. There is no other way to determine how good these organisms are, how much benefit they will produce in the plant, other than by an efficiency test of this nature.

Q. This efficiency test will tell you whether your strain is fair or whether it is good or whether it is excellent, will it, then?

A. That is right.

126 Q. And having run the efficiency test and having found a strain that is excellent, for instance, do the characteristics of that strain remain with the bacteria so you can depend upon it?

A. Yes, the entire inoculant industry is based upon the stability of these strains. After having determined a strain as being efficient, it stays that way unless the strain is subjected to particular treatment. Those ef-

ficiencies can be altered by several different means, but under proper conditions the efficiency of a culture can be maintained in the laboratory over a period of—well, they have records at the University of Wisconsin that extend back over twenty years, showing constant—

Q. Consistency of strain?

A. Yes, the good strain in 1925 is still good in 1945.

Mr. Thiess: Is that clear, your Honor?

The Court: I think so, although I am just—is that how we measure competitive products, in the character of the strain?

The Witness: Yes, competitive products could be measured on that basis. However, I believe I am correct in stating that all of the companies now engaged in the

127 —that is, any company of any size engaged in the manufacture of commercial culture use only highly efficient strains, and there is probably very little difference in the efficiency of the strains, as used by the companies, but for one to come out and just take the strains and not test them, not know what they will do, and just put them in a culture, may produce some nodules on plants all right but there is no way of telling how much benefit it is going to do to the crop.

The Court: I see. But reputable concerns putting them on the market, they are all good?

The Witness: They use nothing but efficient strains in their culture.

Mr. Thiess: Q. In other words, the efficiency test has got to be made in order to be sure that you have gotten a good strain?

A. That is right.

129 Q. Mr. Bond, I now refer you to another drawing which you made which I would like to have marked for identification as Plaintiff's Exhibit 6 and, using this drawing, will you please—

Mr. Greer: Isn't that No. 5?

Mr. Thiess: (Continuing)—please state how the efficiency of these bacteria affect the ultimate growth of the plant?

(Said drawing was marked Plaintiff's Exhibit 6 for identification.)

A. These charts show the importance of the efficiency tests just described. The chart on the left-hand side is a typical efficiency test conducted in the greenhouse in pots and shows the difference between a good strain, a

fair strain and a poor strain and also shows the amount of nitrogen obtained from the uninoculated controls.

The total milligrams of nitrogen for ten clover plants is indicated by the vertical line.

Q. At the extreme left?

A. No, that is the total milligrams of nitrogen in the plants. That is the line to which the figures are attached, 25, 75, 100, and 125 milligrams.

130 The line at the far left designated by "Nitrogen Fixed" shows the amount of nitrogen that was fixed by these different strains. In other words, it is again the difference between the uninoculated plants and the amount of nitrogen found in the inoculated plants.

Now, to show what this means in terms of field results to the farmer who is using the culture, we made the diagram on the chart on the right-hand side of the page. The squares represent bales of clover hay per acre. Clover hay normally isn't put in the form of bales but it was an easy method of diagramming to show the difference. Alfalfa hay is quite frequently baled.

The uninoculated crop produced, in this particular case, produced seven bales of, say, two hundred pounds each. The good culture of inoculant containing good strains produced a total of fifteen or an increase of eight bales. The fair column only produced twelve bales or an increase of five bales. The poor column only produced an increase of two bales.

This shows the necessity of using highly efficient or good strains in a commercial product. The poor strain did better than the uninoculated control if the farmer hadn't used any inoculant. He would have obtained good results, but he wouldn't have obtained the result he could have obtained with a good culture containing a highly efficient good strain.

131 The Court: Does this show the experiment?

The Witness: This doesn't demonstrate the specific experiment. However, there are articles in scientific journals that indicate the results. These are just arbitrary, good, fair and poor strains.

Mr. Thiess: Q. And what is the economic advantage from a farmer's standpoint in using a very efficient inoculant for his red clover seeds?

A. A very efficient inoculant is going to mean dollars and cents to him. A hundred acres would really mean something so far as the net economic result of using a good

strain compared to a fair or poor one and when that is translated into all the farms using a commercial inoculant, it covers a considerable portion of the crop.

The Court: Well, the cost of inoculant, of course, is insignificant?

The Witness: The cost of inoculant is very insignificant and an inoculant is used by almost all of the better farmers. However, the principal objection to using an inoculant is less in its cost than in the trouble it takes to put it on before they plant the seeds.

The Court: Is that normal?

The Witness: It isn't in red clover but, for example, in the case of soy beans, a farmer as in the past month on account of poor weather might have wanted to get
132 those seeds in; a good day comes along and he wants to get it in.

The Court: How do you inoculate a bushel of clover seed with that? Do you have to have a machine?

The Witness: No, the bushel of seed is placed on a good floor or container and the seed is slightly moistened and stirred up and the inoculant added and again stirred into the mixture or the inoculant may be suspended in water and that suspension applied to the seed and all it requires is mixing.

The Court: It does require moisture?

The Witness: It does require moisture. The directions on the package tells you what is enough moisture to moisten the seed or properly distribute the organisms. The idea is to get this culture spread all over the seed.

The Court: So, every seed, as near as possible, will have some of this?

The Witness: Yes.

Mr. Thiess: Q. You can see it on the seed?

A. The humus or black material is very evident on the seed after it has been inoculated.

The Court: The seed would have to be thoroughly dry?

The Witness: Not enough water is added to appreciably moisten the seed; it is just slightly. It may take a little time for the moisture to dry to handle it properly but there isn't enough moisture there to seriously impede
133 the farmer in planting his seed but he does have to stir it into his seed and one hundred acres of soy beans may take anywhere from one hundred to two hundred

bushels of seed and unless he has a mechanical contrivance, it amounts to a considerable amount of work. Some, of course, inoculate it in the drill box of the planting drill.

Mr. Thiess: Q. Now, prior to the date you made this discovery or invention as disclosed in this patent, was there any commercial practice for inoculating seeds of leguminous plants?

A. Yes, commercial inoculants have been sold for many years, particularly in the single cultures. For years commercial inoculants, prior to application for the patent, were sold as single cultures; that is, there was one culture for clover, one culture for alfalfa and one culture for soy beans and there are still products on the market that are confined to the single culture type.

Mr. Thiess: Q. Now, will you please explain how a stock strain is prepared in accordance—well, put it this way—a stock strain is prepared, using one of your drawings here, for commercial use? Can you use one of your drawings to show that?

This is a drawing which you prepared and I ask that it be marked for identification as Plaintiff's Exhibit 7.

(Said chart headed "Preparation of Humus Type Culture" was thereupon marked as Plaintiff's Exhibit 7 for identification.)

134 Now, when you explain that, go into that rather fully, will you, Mr. Bond?

A. This chart illustrates the preparation of a humus type culture in accordance with the specification of the patent.

Starting with the test tube stock strain 1 which was isolated and tested in accordance with the previous charts, this is transferred to a larger bottle 2, in this case a six ounce bottle slant and the base of the bottle contains this jelly food material for the bacteria. The bacteria grow on the surface of the jelly. The bottle in this case is closed with a cotton stopper to exclude the entrance of contaminating bacteria.

After the bacteria has grown in this bottle for a period of two or three days, a suspension is made by adding sterile water and is transferred aseptically to a sterile atomizer and the bacterial suspension atomized into a plurality of 32 ounce bottle slants illustrated in 3.

These bottles, again, have the jelly food material at the bottom and the bacteria grow on the surface of the jelly. These bottles are incubated for two to ten days and during that period of time a heavy growth of bacteria develops on the surface of this jelly food material.

After this incubation period, due to the fact that the organisms have grown up in large numbers in these
135 bottles and that the entrance of an occasional contaminant at this stage would not substantially affect the bacteria that are subsequently going to be in the finished product, there is a dotted line indicating the sterile conditions; that is, beyond that line it isn't necessary to maintain sterile conditions.

These bottles have water added to them as diagramed in 4 and the jelly is broken up in the water by means of a probe.

This suspension was further incubated from twelve to thirty-six hours to get an additional growth in this water that was added to the bottles. After this incubation period, which is usually over-night or to the following day, the coarse part of the jelly is separated by Filter 5 into a container 6.

This container then contains the bacterial suspension, a milky looking liquid containing the leguminous organisms. This suspension is added to a mixer containing humus and a measured amount of water as diagramed in block 7.

The mixer, as shown in 8, mixes the humus or the inert base and the bacterial suspension and, after the mixture is thoroughly stirred, it is discharged into a drum diagramed in 9 and this finished culture is stored for approximately twelve hours to permit the absorption of the moisture contained in the suspension into the humus. It changes the physical characteristics of the humus by storing it overnight.

136 This finished culture is packaged by automatic packaging machines and we have the finished product. I have some samples somewhere.

The Court: Is it in powder form?

The Witness: I have some here I will show you. The finished product is a powder but it is a moist powder, it isn't dry.

Here is the can. That is the same size container as the one you see in the box. That will inoculate a bushel of

seed. That particular culture is made for soy beans and clover and alfalfa. It will inoculate all three. The finished product—it looks dry. That has approximately thirty-eight per cent moisture in it. It looks dry.

The Court: But it isn't as dry as this package?

Mr. Thiess: That is a dead package.

The Witness: That is not a fair comparison. The packages are dated. These are some samples without dates but here is dates here. Beyond that period the package cannot be used.

Mr. Thiess: We have had that package in our office for a number of years before the suit was tried.

The Court: Most of these products are valuable only for a limited time?

Mr. Thiess: For a limited time.

The Witness: This package is not a finished product. This is the humus itself. I called up and told them to
137. send down some material. The finished product is moist.

The Court: The ordinary person would not know the difference?

The Witness: No. You can not tell by looking at it whether it has any bacteria in it or not. As a matter of fact, the only way you can tell if there is leguminous material in it is to add it to plants.

Mr. Greer: May I interrupt? This also has an expiration date on it just the same as the LEGUME-AID?

The Witness: Yes.

Mr. Thiess: I thought the Judge was interested in that.

The Witness: All the products have an expiration date. The reason for the expiration date is because the product deteriorates. The bacteria is a living organism and, naturally, won't live forever. It has a date on it and, after that, the package should not be offered for sale.

Mr. Thiess: You see, if it is dry, it just drops out of there. (Indicating)

The Court: You have your bacteria dated just the same as coffee?

The Witness: That is right.

Mr. Thiess: I would like to offer these two cans in evidence. I would like to offer the can that has humus in it—

The Witness: That is just humus.

Mr. Thiess: (Continuing)—just humus, not culture,
138 as Plaintiff's Exhibit 8 and I offer the other can that has the three-in-one culture for clover, alfalfa and soy beans as Plaintiff's Exhibit 9.

That is correct for the second can?

The Witness: Yes, that is correct.

(Said cans, so offered, were received in evidence by the Court, and marked respectively Plaintiff's Exhibits 8 and 9.)

Mr. Thiess: This Uni-Culture is the trade mark of the Kalo Inoculant Company for their inoculant.

Mr. Thiess: Q. Now, referring again to Exhibit 7 you have just given the explanation of, will you please state what, if anything, in the way of checking for purity and bacterial number occurs in container 6?

A. Before adding bacterial suspension—

Q. Just a minute.

A. Excuse me.

Q. All right, go ahead.

A. Before adding the bacterial suspension 6 to the mixer 8, samples are taken of the suspension and checked in the laboratory for purity and number of organisms.

139 Q. That is a rather important element of this test or this manufacture?

A. That is a check of the production of the culture.

Q. Now, Mr. Bond, will you kindly state generally the facts and circumstances which led up to the discovery of the invention described in your patent here in suit?

A. Well, in June 1937, Mr. Lusk, President of the Kalo Inoculant Company, discussed with me the possibility of the manufacture of a practical composite or mixed leguminous culture.

I was familiar with the adverse opinion of the authorities in the field in regard to mixed cultures and later that summer, while attending summer school at the University of Wisconsin, I had the opportunity of investigating the literature there in the library of the College of Agriculture and in that investigation I found several adverse references to the use of composite cultures or mixed cultures containing more than one species of leguminous organisms.

In addition to that, there were references in the literature that showed when two or more species of these differ-

ent species were mixed together, they had a definite antagonistic effect which reduced their ability to benefit the host plant. I found nothing to indicate this inhibition did not exist.

Q. Referring to this literature which you studied
140 at the University of Wisconsin which indicated that mixed cultures would not give the same results as single cultures, will you please explain a little more fully what this literature showed that gave you this opinion that mixed cultures would not function as well as single cultures?

A. Well, the literature that attempted to explain why mixed cultures were unsatisfactory indicated that an inhibition or antagonistic effect existed when two or more of the species were mixed together. In other words, a culture that would be very good when used alone, would be very beneficial, would be a highly efficient strain, when mixed with other strains would become less efficient and produce a lower yield than the same strain when used alone.

Q. Now, will you explain a little more fully what you mean by antagonistic or inhibitive effects of one species of bacteria on the other? Do you want to refer to one of these charts in doing that or would you rather do it without a chart?

A. Well, the chart illustrates it very well.

Q. All right, which chart do you want?

A. Well, the "Effect of Inhibition", I believe, is the title of it.

Mr. Thiess: Have you got it? Oh, yes. I would like to have this chart marked for identification as Plaintiff's Exhibit 10.

141 (Said chart entitled Effect of Inhibition in Mixed Culture was marked as Plaintiff's Exhibit 10 for identification.)

Mr. Thiess: Q. Now, using that chart, will you explain a little more fully what you mean by this inhibition?

A. This chart illustrates the effect of inhibition in mixed culture. Figure 1 at the upper left-hand corner shows the effect of using in the greenhouse, that is, the typical results obtained in greenhouse tests with an inhibited strain of bacteria. The uninoculated control contained a small amount of nitrogen.

This inhibited strain, or a strain which was capable of being inhibited, fixed or, when analyzed, contained the total amount of nitrogen shown by the column marked "Single".

However, when this same strain of bacteria was mixed with other strains or other species, a reduction was observed in the total nitrogen found in the plants. That reduction is the loss due to the inhibition. That is the inhibitive effect of the other strains that were contained in the mixture on this one which is indicated here as "Single". It is the same effect as changing a good strain to a poor one.

Figure 2—I am getting ahead of myself on this chart—Figure 2 shows what you would get with a non-inhibited strain of bacteria, existence of which wasn't even
142 known prior to tests we conducted in mixed cultures.

Q. There you met no loss?

A. There there is no loss. The good strain stayed a good strain.

Q. Now, will you explain Figures 3 and 4?

The Court: I don't quite understand the difference between inhibited strain and non-inhibited strain.

Mr. Thiess: Will you explain that?

The Court: The first figure there shows what happened when you mixed the two together and there was a loss due to inhibition?

The Witness: Going through the column, the uninoculated column had no bacteria added to it.

Mr. Thiess: That is column 1?

The Witness: The column marked "Single" had only one strain of bacteria in it; that is, the plant was inoculated with only one strain.

The column marked "Mixed" had this same strain, the same strain as the one marked "Single" mixed with others.

The Court: Yes.

The Witness: Due to the presence of the other bacteria, the "Single" changed from a good strain to a poor one.

The Court: The reaction between the two kinds of bacteria?

The Witness: That is right. The bacteria in asso-
143 ciation with each other reduced the yield.

The Court: Yes, I understand that. Now, over in

Figure No. 2 that didn't happen. Tell me why it didn't happen.

The Witness: Figure No. 2 did not happen because that was selected non-inhibited strains of bacteria.

Mr. Thiess: Q. Will you explain that?

A. A non-inhibited strain is a strain that when tested together with other strains does not produce inhibition.

The Court: One does not affect the other, is that right? One strain does not affect the other?

The Witness: That is right.

Mr. Thiess: Q. Will you just explain now what you did and how you found these non-inhibited strains and the tests you made?

A. Well, the following year, in the spring of the following year, cultures that were prepared from mixtures of different strains were tested in our laboratory or our greenhouse to determine just what effect mixing of these strains would have upon each other and in those tests we observed not only inhibition which was indicated in the literature but we also observed that some strains did not show this inhibition. They did not, apparently, affect each other and, from that, the logical conclusion was that strains could be selected, if they were tested, so a mixed culture could be made, so that a mixed culture would produce a maxi-
144 mum benefit to the crop, whereas if that culture contained an inhibited strain, then a reduction in yield would occur due to this inhibition effect, due to mixture.
145 Mr. Thiess: Does that clarify that? If not, we will go into that a little more fully, later on.

The Court: I think I understand it. I don't understand how he gets the noninhibitive strain.

The Witness: Some strains, when mixed, will reduce the yield and other sets of strains, when mixed, do not reduce the yield.

The Court: Yes; I understand that, and the strain is the—

The Witness: —is the individual organism isolated from the nodule and in the stock test tube.

The Court: That is the organism and the strain applied to the organism, whether it is a good strain, a bad strain, or extra-good strain.

The Witness: Yes, starting out with a good strain in a single culture, it doesn't make an appreciable difference

whether it is an inhibitive one or not; that is, whether it is subject to inhibition.

Used in a single culture it would be a good strain but to use that in a mixed culture without testing it first to be sure that this inhibitive effect is not taking place, the results might be a substantial reduction in the yield of the crops. It was a good strain when used before and be-
146 came a poor one when it was mixed.

Q. (By Mr. Thiess) Even though it was a very good strain for a single culture?

The Court: All right.

Q. (By Mr. Thiess) All right; we will just forget this chart for a moment and I would like to have you explain, just to divert for a moment, what is meant by humus in this art.

A. Humus is a muck soil. This particular humus comes from Manitou, Illinois, and is subjected to a heat treat to dry it out, and it is subsequently ground and screened and bagged, of course, and it comes from a muck soil; its source is muck soil.

The Court: What is the word?

The Witness: Muck, m-u-c-k.

The Court: What does that mean,—a real heavy black soil?

The Witness: Yes; it is a heavy black soil and has a high percentage of organic matter in it. It is decomposed swamp soil.

147 Q. (By Mr. Thiess) Rather good to grow plants in, is it?

A. Plants grow in it very well if it is supplemented; I believe it is deficient in potash, so far as the soil is concerned.

Q. I presume his Honor understands what you mean by this and you have used it throughout, but I think you had better explain what you mean when you refer to host plant.

A. Host plant?

Q. Yes.

A. That is the plant on which a given species of bacteria will form nodules.

Q. Now, you have referred to various articles in the literature that you studied prior to the time that you did your work on these various bacteria, to find inhibition, and one of these is an article by Max Kronberger.

Mr. Thiess: Your Honor, this is a German article and we have stipulated as to the English translation. I would like to offer that stipulated English translation in evidence as Plaintiff's Exhibit 11.

(Said document headed: "On Mutual Retardation and Favoring Between Nodule Bacteria", by Max Kronberger; Bavarian Agricultural Institute for Plant
148 Culture and Plant Protection, Munich, Germany, being a Stipulated English Translation, was thereupon marked as Plaintiff's Exhibit 11 for identification.)

Mr. Greer: The translation or the original article?

Mr. Thiess: The translation, to which is attached the German article.

The Court: Now that is an article that the witness says he studied; do I understand that correctly?

The Witness: Yes.

Mr. Thiess: Prior to the time he made his invention.

The Court: All right.

Q. (By Mr. Thiess) Now referring to this Kronberger article, will you please state what you found in this article with respect to inhibition?

A. This article by Max Kronberger on the Mutual Retardation and Favoring between Nodule Bacteria, published in Praktische Blätter für Pflanzenbau und Pflanzenschutz, Vol. XIV, No. 7, pages 203 through 209, 1936, shows that Kronberger prepared the mixed cultures of all different species of root nodule bacteria and grew them together on jelly slants similar to those we have been discussing here.

He took the pots filled with quartz sand and soil and
149 planted sterilized seeds of the different cross-inoculation host plant groups in the different pots, and he also compared each of these mixtures with the individual strains of bacteria that he used to prepare the mixtures with in the first place.

The results that he obtained,—in every case the mixed cultures had a lower yield in dry weight than the unmixed cultures, the single cultures.

He had a total of six different mixtures containing red clover bacteria with different species of other legume bacteria in combination. In every case the mixture producing lower yield than the red clover bacteria used alone.

He found similar results with alfalfa, serradella, horse bean, peas, vetch, and yellow lupine. These last six plants were only tested with one mixed culture each.

That is, he tried red clover with alfalfa and red clover mixed with serradella, and compared it with the single species,—he compared the mixture with the single bacteria, and in every case in these mixtures, the mixture produced a lower yield than the single culture used alone.

Kronberger concluded that the nitrogen fixing ability of the nodule bacteria and, therefore, the yield of leguminous crop was interfered with by the presence of other species and he also concluded that the use of a universal or a mixed culture for the inoculation of various legumes was a great mistake because this mixture would never give the same increase in yield that could be obtained from the same cultures used alone.

150

This report was from the Bavarian Agricultural Institute for Plant Culture and Plant Protection, Munich, Germany. That is one of the agricultural experiment stations in Germany.

Q. And does this article show any of the percentages?

A. Yes.

Q. Have you got those readily available?

A. Yes; in the case of red clover and alfalfa, when he mixed alfalfa with the red clover bacteria, a 9.25 percentage decrease was obtained, in comparison with the same red clover bacteria when used alone.

This decrease was based on the total yield of the plant. In this case he didn't take into consideration the uninoculated controls.

Based on the difference that he obtained with the culture single compared with the culture mixed, there was a 25% decrease due to the mixture of the two strains.

In the case of alfalfa plants, the alfalfa plants inocu-

151

lated with a mixture of alfalfa and red clover bacteria he obtained a 21.54% decrease under the host culture, or the single culture, and similar percentages were obtained all down the line. It varied from approximately 5% to 35% reduction in yield in every case. There wasn't a single exception.

Q. Now, in this Kronberger article he refers to some work done by Hiltner. Did you look up that article at the time to determine what Hiltner had to say?

A. Yes; L. Hiltner, in a paper on the development of crop yield, especially of serradella, through inoculation with nitrogen,—this was a product prepared by Hiltner in Germany. This was published in the Jahrbuch der Deutschen Landwirtschafts-Gesellschaft, Volume 23, 299-301, in 1908.

This report was given at a meeting of the Agricultural Society at Stuttgart on Friday, June 26, 1908.

A. (continued) Hiltner observed that frequently the previous crop of legumes affected the yield of the following crops, and was familiar with other observers or other
152 investigators who observed the same thing.

He referred to two other references in the agricultural press,—this is the German agricultural press—in which red clover was a failure after previous crops of vetch or peas, but not after field beans.

He also observed that Spanish peas failed after growing on a field where vetch had previously grown. Investigating the reasons for this he tried some experiments in pots similar to the pots that we have here and in the presence of red-clover bacteria, serradella seeds inoculated with serradella bacteria show a marked decrease compared with serradella bacteria used alone.

Mr. Greer: May I interrupt? As I understand it he is not referring to the Kronberger but to the Hiltner article.

The Witness: I am referring to the Hiltner article; that is correct.

Mr. Greer: Do you have that Hiltner article here? I do not think it is proper for him to say what the Hiltner article says unless it is going to be introduced into evidence.

Mr. Thiess: We have the Hiltner article here. If you want it introduced in evidence,—we thought it might be well if he would just comment on it.

153 Mr. Greer: We certainly do if he is going to comment on it.

The Court: Without offering it into evidence you can produce it and submit it to counsel.

Q. Now Kronberger also refers to an article by Weigert and Weizel.

Mr. Thiess: And we have a copy of that that we will supply to Mr. Greer. That is the article referred to in the Kronberger article.

154 Q. (By Mr. Thiess) Now, will you please state what this article concludes?

A. This article, by J. Weigert and H. Weizel, entitled: Observations on the influence of previous and cover crops on the development of red clover, was published in Praktische Blätter für Pflanzenbau und Pflanzenschutz, Volume 12, pages 243 through 249, 1935.

This is another report from the Bavarian Institute for Plant Culture and Plant Protection, Munich, Germany.

Weigert and Weizel observed in field experiments that red clover was greatly affected by the previous crop that had grown on the field.

Field beans had an extremely marked— That is, a previous crop of field beans appreciably reduced the yield of red clover which was planted there the following year.

Also in another field planted to red clover along with a cover crop the previous year he had grown potatoes and alfalfa and in that field they had grown potatoes in the previous year a substantial yield of red clover was obtained.

On that part of the field which grew alfalfa there was a very marked reduction in yield.

In his conclusions the authors suggested an investi-
155 gation should be made on the reduction of clover through microbiological means.

By that they were suggesting, or I interpret it this way, that they were suggesting the possibility of the root nodule bacteria being a factor there.

Subsequently Kronberger did his work to check back to see if the root nodule bacteria were a factor in the reduction of that yield. I believe that covers that article.

Q. And then there is another article referred to in the Kronberger paper which is Gerlach and Vogel; is that correct?

A. That is correct.

Q. And what does that article state about inhibition?

Mr. Thiess: (handing paper to counsel) We have handed counsel a copy of the Gerlach and Vogel article, with a translation.

A. Gerlach and Vogel, in a paper entitled: Observations on the Action of Hiltner's Pure Culture for Legumes, published in the Centralblat für Bakteriologie, Parasitenkunde und Infektionskrankheiten, Second Part, Volume 20, pages 61 through 71, in 1908.

Gerlach and Vogel had made an experiment in the pre-

vious year in which they had inoculated and uninocu-
156 lated plants of lupine, soybeans, and serradella in parcels,—they called them. They were masonry structures containing a mixed sandy soil, and they obtained a marked increase due to the effect of inoculation, but the following year they planted in these parcels lupine plants inoculated only with lupine bacteria.

They started out investigating the moisture relationship demand of the lupine plants, but during the year they observed that the lupine seeds inoculated with the lupine culture planted in the parcels of the previous year had serradella bacteria in them and were carried over to the following year, there was a marked increase in yield.

However, where the soybeans had been in in the previous year and the soybean bacteria had been in, there was a marked reduction in yield, when the lupine was planted in these parcels and inoculated with the lupine bacteria.

Well, in their conclusions they indicated that serradella and lupine were of the same cross-inoculation group, or they thought their experiments indicated they were, and in all probability, in the light of our current knowledge, the increase in serradella was due to the more efficient strains
of serradella organisms than the lupine organisms
157 which were deliberately added to the culture.

At this time the differences in efficiency of strains wasn't definitely established, and they also concluded that lupine bacteria following soybeans were either completely destroyed or rendered wholly inactive, indicating that their conclusions from their own observations were that the lupine organisms were affected by the soybean organisms which were left there from the previous year.

Q. Now there is one other article referred to in the Kronberger article. Does that have any bearing on it?

A. That article is by Heinze. On investigation there was no indication, in the Heinze article, of distinct antagonism or inhibition.

He reported a lack of formation of nodules on, I believe it was, clover following peas, and some other crop, but if there weren't even enough organisms there to form nodules, it would be difficult to measure the inhibition effect; there probably weren't organisms there, so I didn't take that paper into consideration.

Q. Well, I now wish to refer you to an article or report

by A. G. Lochhead, of the Department of Agriculture of the Dominion of Canada, Division of Bacteriology, published in 1934, and ask you to summarize the results
158 which are referred to in the report with respect to mixed cultures.

Mr. Thiess: I would like to offer this in evidence as Plaintiff's Exhibit 12.

(Said pamphlet entitled Division of Bacteriology, Progress Report of the Dominion Agricultural Bacteriologist, by A. G. Lochhead, B.A., M.Sc., Ph.D., for the years 1931, 1932 and 1933, was marked as Plaintiff's Exhibit 12, for identification.)

A. The progress report of the Dominion Agricultural Bacteriologist for the years 1931, 1932 and 1933: On page 9 of this report, under the title: Examination of Miscellaneous Inoculants, Lochhead concluded as follows:

"Furthermore, cultures containing bacteria for treating legumes of different cross-inoculation groups were unsatisfactory. Where two strains of Rhizobia are mixed in a single culture there is the probability of one strain being suppressed and it is therefore recommended that an inoculant contain bacteria of but one cross-inoculation."

He very definitely advised against the use of composite cultures.

Q. Now to what extent, if any, to your knowledge,
159 are these reports of the Dominion of Canada Department of Agriculture circulated in the United States?

A. These are circulated throughout the libraries of the agricultural colleges and the agricultural experiment stations.

160 Mr. Thiess: Q. I now wish to refer you to the book entitled "Root Nodule Bacteria and Leguminous Plants", by Edwin Broun Fred, Ira Lawrence Baldwin, and Elizabeth McCoy, published in Madison, Wisconsin, in 1932. Will you state how this publication is regarded by men skilled in the art?

A. This publication is regarded as a standard reference text in the field of root nodule bacteria and the relationship to leguminous plants.

Q. I now wish to refer you to photostatic copies of pages 244 and 245 of this book, and ask you to kindly state what these authors say about mixed cultures, and I would

like to introduce this photostatic copy of those pages, together with the title page of the book, in evidence as Plaintiff's Exhibit 13.

(Said pages 244, 245 and 254 of the book entitled Root Nodule Bacteria and Leguminous Plants, by Edwin Broun Fred, Ira Lawrence Baldwin and Elizabeth McCoy were marked as Plaintiff's Exhibit No. 13.)

161 Mr. Thiess: Q. Now, will you refer to the photostatic pages that are received in evidence as Plaintiff's Exhibit 13 and state what these authors say about mixed cultures?

A. Well, on page 244:

"Composite culture: The desire to have one culture for several crops has led to the preparation of the so-called 'dual purpose' or 'universal culture', Bredemann, 1912, and Vogel, 1917. In some such preparations, rhizobia of only two or three cross-inoculation groups are included, while in others the makers have gone to the extreme of mixing representatives of all of the more common cross-inoculation groups. Although this method may bring about fair nodule formation, the results are variable. The writers feel that composite cultures offer few advantages and certainly many disadvantages. Perhaps the only justification
162 for the mixing of strains is in the case of the small-size garden culture. Because of the limited amount of seed to be sown, it may be desirable to have one culture containing the organisms for such crops as beans and peas and thus to reduce the cost of inoculation."

Q. Now, before you go to page 254, will you explain a little more in detail what is meant by these small sized garden cultures that are referred to in this article?

A. Well, the garden cultures are mixed cultures containing two or more species of legumes commonly grown in the home vegetable garden, and also includes certain legume flowers. The most important of the garden legumes that are inoculated are sweet pea flowers and lupine flowers and garden beans and garden peas, and in addition there are cultures prepared to benefit lima beans and edible soy beans.

Q. What is the fundamental distinction between this so-called garden culture and the field culture that we are interested with in this case?

A. Well, the fundamental difference between the field and garden cultures is that the—well, the garden culture is intended to be used in small quantities. That is, the package that we prepare, for example, for garden inoculants, contains one ounce and is recommended for use for, oh, up to five or ten pounds of seed. Usually the purchaser of a garden inoculant package uses it on a small package of seed, and the size of the package is not important; that is, there is usually an adequate amount of material there to thoroughly inoculate these seeds.

163

But the importance of the culture economically,—that is, so far as its benefit is concerned, garden cultures do benefit the garden crops and flowers, they do produce an increase over what the back yard garden would get without using a culture, but no one has been interested enough in these garden cultures to determine whether he is going to get that maximum benefit. It is really important with the field crop culture.

To the best of my knowledge there are no tests in which the individual species contained in the garden culture has been tested alone and in combination. Most commercial companies, or at least I will speak for our company in regard to garden cultures; we do test the individual species that go into—or we did prior to the patent, we tested the individual species to make sure the species going in there were good, and then simply mixed them together and sold them as garden inoculant. We did not know what effect the mixing them together may have.

164

The Court: Q. Have you since learned?

A. We have checked it since that time, yes.

Mr. Thiess: Q. Well, to what extent is this inhibition important in these garden cultures?

A. Well, if a garden culture should contain poor strains, it would still produce some benefit to the gardener, but the loss of a few sweet pea blossoms or a few beans would not appreciably affect the use of the culture. That is, as long as he was getting some benefit out of it, that is the important point.

Q. But when you are talking about field cultures what is the situation?

A. Well, cultures for application to field seeds is approached in an entirely different light, and you have at stake a very definite economic consideration. That is, if a culture for field seed should be made in strains that you did not know were good, it might result in a very great reduction in yield and therefore an actual loss to the farmer in using that culture. Therefore, in presenting a culture where we need an absolutely maximum yield that we can get in crops, the use of efficient cultures is extremely important.

Q. Now, will you discuss page 254?

The Witness: On page 254, about two-thirds of the way down the page, just above No. 1, the authors make the following statement:

"To the authors the value of a culture seems to depend in a large measure on at least five factors.

1. Upon the organism. It is essential that the culture of bacteria contain the proper organism to form nodules on the desired host plant. In general, it is desirable to have only the one type of organism in the culture.

2. Upon efficiency of strain. Select an active strain of the desired organism. Because of the variation between strains in relation to effectiveness, every effort should be made to select strains of the bacteria which are known to be of decided benefit to the host plant, and to keep these tested cultures under conditions which will maintain the organisms in an active state."

Q. Now, as I understand it, these various publications that you have referred to were among the literature which you considered in the summer of 1937 to show that a mixed culture was not a practical inoculant, is that correct?

A. That is correct.

Q. Now, are there any others?

A. Well, there are other references to mixed cultures that were recommended not only for legumes but also for non-legumes. And in general none of these cultures proved satisfactory. Occasionally fair results were obtained, but in most cases, especially those that were supposed to cover everything, they were very unsatisfactory.

Q. Well, have you any of those that you can refer to?

A. Bredemann tested—G. Bredemann, in an ar-
167 ticle entitled "Investigation of the bacterial preparation, 'Kyles, concentrated nitrogen producer' (it was composite farmogerm)" in the book entitled "Jahrbucher", Bredemann tested one of these mixed cultures to determine what legume organisms were present in the culture. He found that there were some, that there was lupine organisms and alfalfa bacteria there in unbalanced quantities, but he could not find any red clover, vetch, horse bean, field pea, sweet clover legume bacteria. He did find contaminants, including a red yeast, a spore-former, a red and yellow cocci, and a small rod shaped organism. The author concluded that the culture was unsatisfactory for the purpose recommended.

Q. Have you any others that you can refer to specifically, or is that all?

A. Well, we have some other references in regard
168 to these mixed cultures that were recommended for all crops.

Q. Have you got those available?

A. Yes.

169 Whereupon, at 5:00 o'clock p.m., an adjournment was taken to Tuesday, June 26, 1945, at 9:30 o'clock a.m.

170 In the District Court of the United States
Southern District of Illinois
Southern Division

Tuesday, June 26, 1945, 9:30 o'clock a.m.

Trial resumed pursuant to adjournment.

171 Mr. Thiess: The first thing this morning, if Your Honor please, I would like to offer all exhibits which have not been offered.

The Court: They may be received in evidence. I have already received 1 and 2, but have not acted on the others.

Mr. Thiess: That is right. They are now received.

(Said exhibits, so offered, were received in evidence by the Court and marked respectively Plaintiff's Exhibits 3 to 13, both inclusive.)

172 Q. Mr. Bond, you have got a copy of the record there, have you not?

A. Yes, I have.

Q. I understood you wanted to make a correction regarding your testimony on pages 163 and 164.

The Court: You are referring to pages of the current transcript?

Mr. Thiess: Of the transcript, yes.

Q. Will you refer to that and make the correction that you desire?

A. Yes, on page — Should I quote what is here and how I want it changed?

Q. That is right.

A. On page 163, the last line on the page, I said:

"we do test the individual species that go into—or 173 we did prior to the patent, we tested the individual species to make sure the species going in there were good, and then simply mixed them together and sold them as garden inoculant. We did not know what effect the mixing them together may have.

"The Court: Q. Have you since learned?

"A. We have checked it since that time, yes."

I would like to change that in that we, prior to the patent we did not test the strains used in our garden inoculant for efficiency. We obtained these strains from a source that we knew was reliable and the strains were recorded as good or efficient strains.

Subsequent to the time the patent was issued, we have tested these strains individually and have confirmed the previous report in that they are good strains but we have not had the time to test them alone and in mixture. These tests, these efficiency tests, require a lot of work and a lot of time.

We directed our efforts to the most important cul- 174 tures in the group. Those were the field legumes but I have not tested the single strains of the garden cultures in comparison with the mixture.

Q. Now, have you finished that, Mr. Bond?

A. Yes, sir.

Q. Now, when we adjourned last night you were referring to the articles in the literature that you had studied in the year 1937. Now, have you any other articles that

show that mixed cultures were unsatisfactory that you found when you made this study?

A. Yes, Doctor Lockheed, Dominion Agriculture Bacteriologist of Canada, in his report for the years 1929 and 1930 for the Division of Bacteriology reported on tests with Growmore which was claimed to be a culture satisfactory for all legumes and found that it did not compare with the single cultures made by his department in the formation of nodules on alfalfa and peas. These were the only legumes on which he tested this culture.

Lockheed in a similar report for the year 1925 on page 16 tested two other cultures of the same type as Growmore on peas and found unsatisfactory nodulation of peas.

Q. Did you say page 16, is that correct?

175 A. Excuse me.

Q. We haven't photostated it as page 16,

A. The test is on page 18. The start of his work is on page 16.

Q. Now, have you any others?

A. Paul Emerson in Bulletin Number 214 of the Maryland State College of Agriculture, Agriculture Experiment Station, reported on tests of an "all crop soil" inoculant.

On page 142 field tests were made with soy beans. The soy bean seeds inoculated with this culture did not produce as great a yield as the soy bean seeds which were not inoculated. This culture was obviously unsatisfactory on soy beans, the only legume on which tests were made.

Doctor L. T. Leonard in a paper entitled "Some Tests With Soil-Gro", it is presumed to be the same culture Lockheed referred to.

In the journal of the American Society of Agronomy, Volume 17, pages 626 and 628, 1925, they found that this alleged all crop inoculant varied from one sample to the next in its formation of nodules on the different legumes.

It also did not increase a crop of peas in field experi-
176 ment tests.

Doctors Conn and Hofer in Circular Number 137, Revised, New York State Agriculture Experiment Station entitled "Soil Inoculant Service" on page 3 states:

> "Whereas in 1931 and 1932 the tests showed that a high proportion of the cultures were unsatisfactory, in 1933 they indicated a much smaller percentage as inferior. This last year the poor products were often

found to be mixed cultures sold in smaller containers recommended for garden purposes."

They also reported on unsatisfactory tests with a number of these all crop inoculants.

There are many tests in the literature indicating that others of these mixed cultures did not form nodules on their respective plants. These are examples of typical
177 references of that nature.

Mr. Thiess: Q. All right. Now, in the light of this study of the literature, what were your conclusions respecting the possibility of producing satisfactory composite or mixed cultures for leguminous plants?

A. Well, I found these many references which showed that mixed cultures for legumes as well as non-legumes were not satisfactory.

Kronberger and his Accessory References, namely, Hiltner, Gerlach and Vogel, and Weigert and Weizel, as well as Lockheed, Fred, Baldwin and McCoy strongly indicated the existence of antagonism or inhibition when different species were grown together.

From these references I concluded that the use of mixed cultures for field seeds was an impossibility.

I think that sums it up.

Mr. Thiess: Q. And having arrived at this opinion what, if anything, did you do in view of Mr. Lusk's instructions to you to produce a composite or mixed culture for leguminous plants?

A. Well, I told Mr. Lusk that although I thought a satisfactory mixed culture could be prepared that
178 would contain all the different species in adequate number to thoroughly inoculate the respective host plants for which they were recommended, we would still have this problem of antagonism or inhibition entering into the picture and the culture would not produce optimum results when used in the field.

Q. And having so informed Mr. Lusk, you then made the tests you referred to yesterday?

A. Yes. Mr. Lusk suggested the least we could do would be to try it and see to what extent this inhibitive or antagonistic effect would carry through into the culture.

Q. And what conclusions did you draw as a result of your tests?

A. The tests that following fall, the fall of 1937, I prepared several different mixed cultures with different strains and of different species mixed together and the first test was set up in the late fall of 1937 and, due to the fact we did not have supplemental lighting in the greenhouse, it was discarded. None of the plants showed sufficient growth to tell the difference between inoculated and uninoculated control.

The second experiment was set up in the spring of that year and in that experiment we found that certain 179 strains would inhibit others in a mixed culture, corroborating the evidence that was already in the literature but, in addition to that, we found some of those mixtures did not cause those inhibitions, did not reduce the yield, which showed to me if they were selected and proper cultures made, satisfactory cultures could be made.

In the meantime I run tests to see if there were an adequate number of these organisms present to form nodules but even at dilutions fifty times that recommended on the package nodulation was obtained on all these species that were included in the mixture.

Q. Now, are there any other publications than those you considered in 1937 which indicate that inhibitions exist?

A. Yes, in the report of the Dominion Agriculture Bacteriologist, A. G. Lockheed, for the years 1934, 1935 and 1936, on page 15 he made the following statement at the bottom of the page. This is under the sub-title "Examination of Miscellaneous Inoculants".

> "Moreover, inoculants containing bacteria for but one cross inoculant group are believed better than 180 those containing bacteria for two or more leguminous groups, since tests have shown that in mixed cultures one strain may become effective."

This report was published in 1938.

Another paper indicating the influence of the different strains of root nodule bacteria on each other, even within the same species, was published in the Journal of Agricultural Research, Volume 46, 1933. This paper is entitled "The Effects of Non-beneficial Nodule Bacteria on Austrian Winter Peas", and is by L. T. Leonard and W. R. Dodson.

On page 658 there is a table on the nitrogen fixed by different pea cultures on Austrian winter peas. Two of the—all of the tests were on individual strains except in one case a mixture of two strains was included.

This mixture of two strains produced a lower yield than either one of the strains used alone, indicating that the association of the two strains together produced a marked inhibition on either one or both. This inhibition in one case amounted to 95 per cent—these figures on inhibition are my own, I just took the data and calculated the
181 degree of inhibition here—and on the other strain amounted to 85 per cent.

The authors state:

> "When the two types of organisms (512 and 513) were used together the total nitrogen fixed was not greater than that fixed by the non-beneficial organism alone."

This paper indicates an amplification of the other literature in that inhibitions may exist not only between species but even between strains within a given specie.

These strains were both pea strains.

Q. All right, Mr. Bond, I wish you would now refer to your patent in suit and state whether or not you have enumerated therein any of the data which you obtained as a result of the tests you conducted which proved to your satisfaction that there were inhibitive strains. And I call your particular attention to page 4 of the patent, column 1 through column 2, line 56.

182 The Witness: Yes, I see. The easiest way to give these tests would be merely to read what is in here.

The Court: The question is, did you refer to them in your patent?

Mr. Thiess: Q. Did you refer to them in your patent, the tests you made prior, that you have been talking about?

A. Yes.

Q. Did you refer to those in your patent?

A. Yes, I have.

Q. And these tests show what results?

A. Well, these tests showed that certain strains when mixed with other species a definite inhibition was observed but when other strains were mixed with other strains of different species that inhibition was not observed.

Q. And in these tests that you made on page 4, which were made to show this inhibition, what was the percentage of inhibition if it is available that you found?

A. Well, in the case of the soy bean plants the mixture containing inhibitive strains compared with the single strains, the same single strains, the following results 183 were obtained.

There was approximately a 35 per cent increase when the single strain was used as compared with the mixed, that same strain mixed with the others. That is indicated on line 41, column 2.

The same thing was true of the red clover plants. The single strains of red clover produced 118 per cent more nitrogen than the mixture. That is indicated on line 52.

Q. I now refer you to your patent at page 6, beginning with column 1, line 25. Are the test results here indicated results of tests you actually made?

A. Yes, they are.

Q. Will you please state a little more fully what these tests are and what the tabulation you have in your patent indicates?

A. The table starting on line 62 shows the following:

Q. Before you go to the table you had better state how these tests were made.

184 A. These tests were made in the same manner that the efficiency tests were made, as illustrated in Exhibit 5. The first column, Inoculant Series Number, lists the number of the different cultures that were tested.

There is a total of five, one of which was an uninoculated control. The first number, 1, is the uninoculated control. Number 2 is an inhibited strain used unmixed or in single culture.

Number 3 is a noninhibitive strain, also used unmixed or in single culture. Number 4 is the inhibitive strain when mixed with other species, and Number 5 is a non-inhibitive strain when mixed with other species.

The second column refers to the grams dry weight for ten plants, determined in accordance with Exhibit 5.

The third column—

The Court: What is that you are weighing there, grams?

The Witness: Perhaps I can show it better by referring back to this exhibit.

A. (continued) In Exhibit 5 the grams dried weight is obtained from the total weight of the dried plants.

The Court: How is that now; go ahead?

A. (continued) Dried weights are obtained in ac-
185 cordance with box 8 on the diagram. That is, it is the plants similar to these that we have over here where the sand is washed from the roots and those plants are dried and the plants, after they are thoroughly dried, are weighed.

Q. (By Mr. Thiess) The entire plant?

A. The whole plant, yes.

The Court: All right.

A. (continued) And then the dry weight per plant can be determined merely by dividing by the number of the plants in the pot and can be converted to ten plants, 100 plants, or any unit.

10 was a convenient figure in this chart because it was easier to figure in the subsequent calculations.

Column 3 indicates the percent nitrogen in each of these samples and the percent nitrogen was determined in accordance with box 9 in Exhibit 5. The milligrams—

The Court: That means the amount of nitrogen absorbed by the plant?

The Witness: No; that is the total amount of nitrogen that was found in the plant. The plant was analyzed for its nitrogen or protein content.

The Court: Of course this was after the plant has grown.

186 The Witness: The plant had grown. These are the results on grown plants.

Mr. Thiess: Your Honor, you understand that is all nitrogen, some of which is in there due to inoculation and some possibly due to the earth.

The Witness: That is right.

Q. (By Mr. Thiess) Will you continue?

A. From these two figures we obtained the fourth column, milligrams of nitrogen per 10 plants, the product of the grams dry weight times percent nitrogen, gives the milligrams of nitrogen per ten plants.

Q. Will you go to the next column?

A. The last column is the milligrams of nitrogen fixed per ten plants and is the difference between the inoculated series numbers 2, 3, 4 and 5, and the uninoculated series

1; that is, 1 is subtracted from all of the others and that is the actual amount of nitrogen fixed by the bacteria from the air.

Q. Now in column 4 the figures that are marked all carry an asterisk, and the asterisk refers to standard deviation of the mean of a series of five jars.

Now, without going into this in an elaborate manner, will you kindly state what is meant by the standard
187 deviation of the mean?

A. The standard deviation of the mean is a statistic calculated from the samples to show whether differences between the means, that is, differences between the milligrams of nitrogen fixed per ten plants is a real difference or only an apparent difference.

It is an objective method to determine if there is a real difference between these two determinations.

Q. Statistically that is an accepted method of making that sort of a determination?

A. That is correct.

Mr. Thiess: That is, I think, all that your Honor needs, that it is an accepted method.

Q. (By Mr. Thiess) Now you refer there to a series of five jars. Did you use five jars in all of these tests?

A. In checking over the data prior to the patent trial I noticed that Inoculant Series Number 2 and Inoculant Series Number 5 had three replicates in it instead of five.

Mr. Thiess: He means three jars.

A. (continued) Three jars. Three replicates.

However, that does not reduce the significance of the results; that is, as long as the statistic, the standard
188 error of the mean, is determined, samples containing this number of replicates can be accurately compared.

The reason that several jars are used in each of these experiments is that there is an inherent variation between different plants, between the seeds, and to use the single jar would not give you sufficient information to accurately know whether there was any real difference between the uninoculated and inoculated plants.

When the difference is as extreme as we have here, when you compare the differences between inoculated plants it is necessary to run each series that is inoculated in replicates, preferably at least three, and that will give you data to which statistical methods may be applied, to objec-

tively determine whether there is a real difference between your averages or just an apparent difference.

Q. (By Mr. Thiess) Now, what does this table show in your patent with respect to inhibition with respect to the various plants that were tested?

A. Well, the Inoculant Series Number 2 containing the inhibitive strains in single culture fixed as much nitrogen as Number 3, the noninhibitive strain used in single culture, and the noninhibitive strain in Series Number 5 used in mixed culture.

189 Now, there is a difference between these three means, but the fluctuation of the standard error indicates that that difference is apparent and not a real difference.

In this particular test we did not measure any real difference between those three cultures.

The Court: What you are talking about is 2?

The Witness: 2, 3 and 5.

Q. (By Mr. Thiess) Now, will you just so that his Honor will get that, repeat what 2, 3 and 5 are?

A. 2 is the culture containing inhibitive strains alone. 3 is a culture containing noninhibitive strains alone, and culture 5 contains noninhibitive strains mixed with other strains.

Q. And as to those 3 you got—

A. There is no significant difference between those three cultures.

Q. Now, will you go to the others?

A. Culture 4 containing the inhibitive strain in a mixture produced a significantly lower yield than any of the other three cultures; that is, comparing it directly with the same strain used unmixed, that is Series Number 2, there is a distinct loss or distinct effect of inhibition observed there.

190 A mixed culture prepared commercially from the strains used in Inoculant Series Number 2 would produce a culture that would not yield maximum results when used by the farmer in the field.

On the other hand, the noninhibitive strains, Inoculant Series Number 3, did not show any decrease when used in a mixture and as compared with 5, the same strain used in a mixture. 3 and 5 contain the same clover strains where the Number 3 strains were used unmixed; 5, where the strains were used, mixed. There is no significant differ-

ence between 124.5 plus or minus 15.8, and 119.5 plus or minus 39.7.

Q. Now in this data you have referred to in your patent you used the standard deviation of the mean to get your statistical analysis to show what the results would have been if you had carried on over a much larger number of plants.

Have you any other methods, statistical methods, for doing this?

A. Well, an extension of the same method, that is a finer tool for measuring these differences, is a method that is called analysis of variants.

This same standard error is determined on a different basis and is a more accurate estimation of the error
191 that is occurring in the experiment, due to conditions that are either beyond control or induced by the operator himself.

Q. And have you applied this method of analysis of variants to the test data reported in your patent and to other tests?

A. Yes, I have.

Q. And what was the result of applying this analysis of variants to the test results shown in your patent?

A. I obtained the same significant figures that are indicated in the patent by using this method. It is a more extensive method of analysis.

Q. Did you apply this method of analysis of variants to some others of your tests?

A. Yes, I have.

Q. Now, as I understand it, you have some tests which are marked U2-38, is that correct?

A. That is correct.

Q. Will you please give the results that you obtained by applying this analysis of variants to these tests with respect to inhibition?

A. In an experiment, U2-38, on red clover plants,
192 significant inhibition of one set of clover strains was obtained when alfalfa, soybean, pea, bean and lespedeza strains were used.

In this same experiment significant inhibition of a second set of clover strains was obtained when mixed with two other sets of alfalfa and soybean strains.

Q. With what result?

A. Significant inhibition was obtained. In this same experiment, U2-38, on soybean plants, significant inhibition of a set of soybean strains was found when they were mixed with clover, alfalfa, pea, bean and lespedeza strains.

In an experiment, U2-38, on Austrian pea plants, a significant stimulation of a set of pea strains mixed with clover, alfalfa, soybean, bean and lespedeza strains was obtained.

Q. Will you explain what you mean by that?

A. By stimulation there was a significant increase in yield when these pea strains were mixed with the others.

This is an additional effect that I did not know of at the time the patent was applied for, and there was no indication of it in the literature, and I was very much surprised to find it as well as even to find that no inhibition could exist.

193 But to find in addition to that,—you may even in certain cases get stimulation, was just another indication that the association of organisms together can definitely influence the nitrogen fixing characteristic of the particular strains.

In some cases it will lower it and in some cases it may increase it. In other cases there is apparently no effect.

Q. And that therefore it is necessary to make an efficiency test on these strains, combined so as to know that your ultimate results would be satisfactory?

A. If an efficiency test is not made to determine that the final product is producing optimum yield, there is no way of knowing what it will do when it is finally used in commercial use.

Q. Now, have you some other tests?

A. In U2-38 on alfalfa plants two different mixed cultures produced no significant inhibition or stimulation.

In an experiment later the same year, U3-38, on red clover plants, significant inhibition of a set of clover strains when mixed with alfalfa and soybean strains was obtained.

In this same experiment on soybean plants, that is, 194 U3-38, significant inhibition of soybean strains was found when these were mixed with clover and alfalfa strains.

In another experiment, conducted in 1940, U1-40, on clover plants, a significant stimulation of one strain of clover by one strain of soybeans was observed.

The Court: That means mixing of the soybean and the clover?

The Witness: Yes.

A. (continued) That soybean strain was mixed with one clover strain. On clover plants the clover was tested alone, and the clover plus the soybean strain were tested together, and a significant stimulation,—an increase of yield was obtained in the presence of that soybean strain.

The Court: When was that experiment made?

The Witness: That experiment was made in 1940.

The Court: After the patent?

The Witness: This was after the patent.

Mr. Thiess: All these are further tests that he made to show—

The Court: I understand. Your product here is a combination product covering soybeans, clover and alfalfa, isn't it?

The Witness: We have two products. One of them is 195 recommended for alfalfa, clover and soybeans.

The second product is recommended only for alfalfa and clover; there is a different demand for the different products in different areas, different territories.

The Court: The patent in suit here—is it limited in its claims?

Mr. Thiess: No, it is not. The patent is not limited in its claims.

The Court: And limited to any particular combination?

Mr. Thiess: No; under the claims in suit.

Mr. Greer: It is not dependent upon or rather it is dependent upon what you mean by limits. There are some of the claims that are limited to the alfalfa and the clover group and some of them have limits as to the effect on the alfalfa bacteria. Then there are others that say that there is no limitation and that there is no inhibition in his product as to all of the groups, so that your Honor's question cannot be answered specifically as to all of the claims.

Mr. Thiess: We are saying merely that the claims in suit—

Mr. Greer: I mean the claims in suit.

Mr. Thiess: —are not limited to three or more 196 strains of bacteria.

The Court: The claims in suit are 1, 3, 4, 5, 6, 7 and 8, 13 and 14?

Mr. Thiess: That is right.

Mr. Rathburn: None of them mention specifically any Rhizobia except trifolii.

Mr. Thiess: They call for trifolii and other species, which can mean clover, alfalfa and soybean.

The Court: Those are the claims in suit because they are the ones that it is contended the defendant has depended upon and Captain Greer told me in the opening statement that all claims were asserted to be invalid.

Mr. Thiess: No.

Mr. Greer: Under our counter-claim there we set up the invalidity of the whole patent.

Mr. Thiess: Yes, in their declaratory judgment counter-claim. They have a counter-claim in this suit.

The Court: Asking for a declaratory judgment upon the entire patent.

Mr. Thiess: Yes, on the entire patent.

The Court: And, of course, that does put in issue all claims of the patent.

Mr. Greer: Yes, it is not only these claims it is
197 specified, that it is claimed are infringed, but the validity of all of them are before your Honor.

Mr. Thiess: Under the counter-claim.

The Court: Maybe you told me but I don't remember your telling me there is a counter-claim asking for a declaratory judgment.

Mr. Greer: I didn't specify it as a declaratory judgment but I did state in our counter-claim we attack the validity of all the claims.

The Court: I know you said the validity of the patent as a whole was involved and that is what I was a little confused about.

Mr. Greer: That is what it is.

Mr. Thiess: I might say, just in view of your Honor's question, not only is this in the claims, but on page 5 of the patent, column 1, the sentence beginning on line 44, which reads as follows:

> "A composite culture that is satisfactory for use for inoculating seeds of alfalfa, red clover, and/or soy beans (representatives of three cross-inoculation groups) contains a mixture—"

and then he refers to these chief Rhizobia bacteria, so that means either the two or the three. They have the
198 preference. You can either add the soybean or not to the alfalfa and the red clover strains.

And it might be advantageous at this time to just read your Claim 1. This claim reads as follows:

> "1. An inoculant for leguminous plants comprising a plurality of selected cultures of different species of bacteria of the genus Rhizobium, one of said cultures being Rhizobium trifolii alpha,—"

Now Rhizobium trifolii alpha is the clover strain of the noninhibitive type. Alpha has been so explained in the patent,

> "—said cultures being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific."

Now that claim will read on any mixed culture in which the strains are selected so that you will have noninhibitive strains and will not get inhibition and get a composite culture that would be as efficient as the single culture if the Rhizobium was used as a single culture.

Is that sufficient, your Honor?

199 The Court: Yes.

Q. (By Mr. Thiess) Now, I believe you were referring to your test that you made in 1940 which is referred to as U1-40?

A. That is correct.

Q. Will you just cover those?

A. The reference was to experiment U1-40 on clover plants. Significant inhibition of a second strain of clover was observed when mixed with one strain of alfalfa. Significant inhibition of this same strain of clover was also detected when mixed with one other strain of soybean.

In this U1-40 experiment on alfalfa plants, significant stimulation of one strain of alfalfa by one strain of soybean was observed, and significant stimulation of a second strain was observed, that is, significant stimulation of a second strain of alfalfa by this same strain of soybeans.

Significant inhibition of one of these strains of alfalfa when mixed with three strains of clover and three strains of soybeans was also observed.

In this U1-40, the experiment on soybean plants, significant inhibition of one strain of soybeans by one strain of clover was recorded.

200 Significant inhibition by this same strain of soybeans by a second strain of clover was observed and

significant inhibition by this same strain of soybeans, or, rather, of this same strain of soybeans by a third strain of clover was observed.

This particular strain of soybeans apparently was very sensitive to the presence of these other organisms.

The Court: And when you say a significant inhibition was observed, that means it was not good?

The Witness: That was not good. That mixture was not good. That is a strain not to use in a mixture containing these particular strains.

Significant inhibition of this same strain of soybean was noticed with one strain of alfalfa and significant inhibition of this same strain of soybeans was noticed with the second strain of alfalfa.

Significant stimulation of a second strain of the soybeans was observed with the mixture of one strain of clover, and significant inhibition of this second strain of soybeans was detected with another strain of clover.

Here is the same strain of soybeans when mixed with one strain of clover and there is an apparent stimulation, a significant stimulation and when mixed with another
201 strain of clover it was inhibited.

In other words, each strain in this mixture must be selected so as not to inhibit or be mutually inhibited by the other organisms.

A significant stimulation was obtained in these soybeans with one strain of alfalfa.

202 Q. Now, I wish you would please refer to the drawings in the patent and correlate them with the tests, if that is correct, that you have just referred to and are recorded in the table in your patent.

A. You are referring to the drawings on the face of the patent?

Q. That is right.

A. Figure 2 is a sample of plants obtained from one of the replicates from series No. 1, the uninoculate control series. No bacteria were added to these plants. Figure 3 is a photograph of plants from one pot in series 3, which were inoculated with a noninhibitive strain used alone, in a single culture. Figure 4 are plants taken from a pot in inoculant series No. 5, inoculated by a non-inhibitive strain mixed with other species.

There was no significant difference between the plants

shown in Figure 3 and Figure 4, showing that by the selection of a non-inhibitive strain a satisfactory composite inoculant could be made that would produce the same results as a satisfactory single culture. You see, Figure 3 is a single culture and Figure 4 is a mixed culture.
203 There is no significant difference between those two groups of plants.

Q. Now, is it ordinarily satisfactory to rely upon a visual inspection of the plants to determine whether the single and mixed cultures are satisfactory?

A. No, a visual inspection can give a rough idea of gross differences between cultures, but it is necessary to run through a specific efficiency test, in which dry weights are taken and the percentage nitrogen determined, in order to detect differences smaller than 20 per cent.

Q. And the efficiency test is the one that you have shown in Exhibit 5?

A. Exhibit 5.

Q. And described.

The Court: Q. What is Figure 1 on the patent?

A. Figure 1 is the uninoculated control plants. They had no bacteria added to them.

Mr. Rathburn: That is Figure 2.

The Witness: Oh, excuse me. Figure 1 is a drawing to show the nodules on the roots of the plant, and was taken from this book "Root Nodule Bacteria and Leguminous Plants", by Fred, Baldwin, and McCoy. It is on page 176 of this book. It was merely introduced to
204 illustrate what was meant by nodules on roots.

Mr. Thiess: Q. And the Figure A, referring to that nodule, is the same as the nodule we showed on the living plant we had here in the courtroom yesterday?

A. That is correct.

The Court: On that claim 1, for example, you are claiming in the patent, it is a process, isn't it?

Mr. Thiess: No, it is a composition of matter or manufacture.

The Court: It is a composition of matter, yes.

Mr. Thiess: We are not relying on the process claims, if your Honor please.

The Court: I see.

Mr. Thiess: All of our claims are product claims.

The Court: You claim there, "An inoculant for legumi-

nous plants comprising a plurality of selected cultures of different species of bacteria," but you don't undertake to select or limit the claim to any particular selection, do you?

Mr. Thiess: Oh, yes, we do, of the genus Rhizobium. Now, the Rhizobium is that family.

The Court: The genus Rhizobium.

205 Mr. Thiess: That is the family of this bacteria that affect leguminous plants.

The Court: Oh, one of the cultures being Rhizobium—

Mr. Thiess: —trifolii alpha. Now, Rhizobium trifolii alpha is a non-inhibitive strain. You will remember, I think, that in my opening, and Mr. Bond will undoubtedly —I will have him discuss this later on; the patent says on page 5, column 1, line 36, "The organisms of the genus Rhizobium which are mutually non-inhibitive may be designated by the term alpha."

The Court: Yes.

Mr. Thiess: And hence by using that alpha in the claim we mean a non-inhibitive strain.

The Court: Yes. But you say, "a plurality of selected cultures of different species of bacteria of the genus Rhizobium."

Mr. Thiess: Yes.

The Witness: That means red clover species, alfalfa species, soy bean species. They are considered individual species and they all belong to the same family or the same genus which is assigned the terminology Rhizobium. It is merely a subdivision in the bio-

206 logical classification.

The Court: And "being unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific." There can't be, you say, a different species of bacteria of that one genus?

Mr. Thiess: Now, there are different species of bacteria of the genus Rhizobium.

The Court: Yes.

Mr. Thiess: Now, in this particular inoculant (Pl. Exhibit 1) we have got the two species, and they are referred to right here. The alfalfa group. For alfalfa, sweet clover, hubam, southern bur clover, and black medic. That is one of the cross-inoculation groups. You will remember the cross-inoculation group. That is the alfalfa cross-inoculation group. This also contains the clover group; for red, alsike, white, mammoth, ladino, hop, and crimson clover.

Now, you have in this particular inoculant those two species, and since this inoculant is as good as an inoculant that is used as a single culture, you have a multiple culture doing the same work. You have these alpha strains in here that give you the same result as
207 though it was a single culture.

The Court: Yes, I understand that part, but the thing that is bothering me is where it says "different species of bacteria" without saying which ones are included in the inoculant claim.

Mr. Thiess: Well, that is a broad claim. Persons might combine—this patentee having discovered that, or invented that there are these non-inhibitive strains, you could make up a composite culture of merely the clover and alfalfa strain, or you could make up one with a three and one strain, or you might make up one with a four and one strain; but as to all of these it is necessary to have these alpha strains, and hence the patentee is entitled to a broad claim covering any culture in which alpha strains, non-inhibitive strains, are used for the purpose of getting a successful mixed culture.

The Court: All right.

Mr. Thiess: Well, you understood that—Mr. Neumann just called my attention to the fact that the claim specifies that one at least must be clover, in claim 1.

208 The Court: Yes.

Mr. Thiess: You see, the Rhizobium trifolii alpha is the non-inhibitive clover strain.

The Witness: One of the reasons for that is that in previous literature the majority of the work was directed toward red clover. That is, red clover was one of those that was producing this inhibition, that was inhibited by the others.

Mr. Thiess: Does that clarify the matter?

The Court: I think it does, except I am still uncertain about this, where it says "a plurality of selected cultures." Does it make any difference which culture you select or use?

The Witness: As long as you test it to make sure that it is an alpha culture, one that will not be inhibited by others or will not inhibit others.

The Court: Well, when you say it is an alpha culture, you mean it is a red clover culture?

The Witness: No, alpha refers to the fact that it will not be inhibited.

The Court: The Rhizobium trifolii means red clover?

Mr. Thiess: That is right.

The Witness: That is right.

209 The Court: You are claiming here a plurality of selected cultures, but you don't otherwise designate the particular cultures you use, do you?

The Witness: No, this claim would cover a culture that would contain clover and alfalfa, or clover and alfalfa and soy beans, or clover and soy beans, or clover and peas, any combination in which clover was included.

The Court: Anyone preparing that product would have to make their own tests to see whether they were inhibitive.

The Witness: That is the important part of the claim, that is, your culture would have to be tested to determine that the strain was non-inhibitive before being prepared. It covers the culture so prepared in that manner.

The Court: You could prepare a culture under claim 1 and it might not be useful at all?

The Witness: Not under claim 1, because the culture has been selected so that it will be used. It has been selected, or the strains in it are selected so that it will not be inhibited by or will not inhibit the other strains.

210 The Court: Well, you say that there are a series of cultures, a plurality—

Mr. Greer: May I interrupt? I think I have a thought that would clear the matter up in your Honor's mind, concerning which there ought not to be any conflict between Mr. Thiess and myself.

The Court: All right.

Mr. Greer: The use of the expression in claim 1, and in all the others, of "selected cultures" is explained in the specification, and that means that Mr. Bonds admits that in these strains of clover bacteria, we will say, which is the trifolii group, there is one strain that is a poor nitrogen fixer. You will agree with that, won't you, Mr. Bond, there is one strain that is a poor nitrogen fixer and there is another strain that is a high nitrogen fixer? There are various strains of this clover group, in other words?

The Witness: Yes.

Mr. Greer: And some of them are high fixers of nitrogen and some of them are low fixers of nitrogen, though they do fix nitrogen.

The Witness: Yes.

211 Mr. Greer: Now, what he means by "selected strains" is that he has performed tests of the single culture of the clover bacteria and picks out from that, as a result of that test, a strain of the bacteria that is the high fixer of nitrogen. That is his selection that is mentioned in the second line of the claim there, of selected cultures.

The Witness: No. In addition to that the culture is further tested in a mixture to make sure that a high efficiency is going to be maintained.

Mr. Greer: That is the alpha.

The Witness: Yes.

Mr. Greer: But the first selection—

The Court: The selected culture means that he has selected it by experiment.

Mr. Thiess: That is right.

Mr. Greer: He has selected it by experiment as being one that he found by a previous test to be a high fixer of nitrogen itself. Then his alpha test is the second part of it.

The Court: There is no better way, I suppose, to identify the culture than to say that it is a selected culture, selected being—

212 Mr. Thiess: Being the approved methods in this art.

The Court: Yes.

Mr. Greer: Yes. I did not mean to interrupt.

Mr. Thiess: That is all right.

Mr. Greer: But it seems to me that that would help clear it up.

The Court: Yes, it will be very helpful. You may proceed.

Mr. Thiess: Q. Now, Mr. Bond, have you any photographs in which the inhibition was great enough so that it could be readily seen from the plants themselves?

A. Yes.

Mr. Thiess: I ask the Notary to mark this for identification as Plaintiff's Exhibit 14.

(Said photograph was thereupon marked as Plaintiff's Exhibit 14 for identification.)

Q. Will you now please explain what this Exhibit 14 is and what it shows?

A. Exhibit 14 is a photograph of clover plants grown

in three different pots. The first pot comprised an un-
inoculated—or plants to which no inoculation was
213 applied. They are the control plants, and there are
forty plants in each one of these groups. The second group of plants were inoculated with strains 18 and 19, used alone, unmixed or in a single culture. The third group of plants were strains 18 and 19 mixed with other strains of bacteria, and there is a definite reduction in yield due to the fact that these same strains 18 and 19 were mixed with other species. The association definitely reduced the amount of nitrogen fixed and therefore the yield of the plant.

Looking at the figures that were subsequently obtained, the uninoculated control plants contained 40.4 plus or minus 2.0 milligrams of nitrogen, but the plus or minus is the standard deviation of error. That means the figure is probably significant, from 42.4 to 38.4. It gives a range.

Strains 18 and 19 used unmixed contained a total of 141 plus or minus 11.6 milligrams of nitrogen, and strains 18 and 19 mixed with other species contained 86.7 plus or minus 5.2 milligrams of nitrogen.

The Court: Q. You don't say what they are mixed with.

A. No. These were mixed with another set of alfalfa
strains and clover and soy bean strains. There
214 were three species in this culture.

Q. You got into the soy bean strain or soy bean culture.

A. In many of the tests we have soy beans included in the mixture. This product here (Pl. Exhibit 9), this uni-culture, is for clover, alfalfa, and soy beans. That is the development of some of these tests.

Q. Soy bean is in a different group?

Mr. Thiess: Cross-inoculation.

The Witness: Yes, and so is alfalfa in a different class than clover. Alfalfa and clover are in different classes.

The Court: Are they?

The Witness: There are three species represented there, clover, alfalfa, and soy bean.

The Court: In this product there?

The Witness: In this product, in the uni-culture.

Mr. Thiess: You see, these cross-inoculation groups, if your Honor please, are referred to very clearly on page

1 of the patent, in the last paragraph in column 2, and inasmuch as that is rather important I believe it might be well just to look at that for a moment.

215 The patentee says, beginning on line 34:

> "Thus certain species of bacteria are specific to certain species of Leguminosae. The group of plants that will be infected by a single species of bacteria has come to be known in the art as a cross-inoculation group. There are at least six well-recognized species of Rhizobium which will infect six fairly well defined cross-inoculation groups of plants."

Then he goes on to explain.

> "Rhizobium meliloti will infect alfalfa and white or yellow sweet clovers."

Now, that is the cross-inoculation group that Captain Greer referred to as the alpha group, but that also does inoculate white or yellow sweet clovers. Now you come to Rhizobium trifolii, which is the one mentioned in the claim that we talked about, claim 1. This will infect red, white, crimson or mammoth clovers.

Now, in that cross-inoculation group we have got those four plants. Then you go to the others. Rhizobium leguminosarum will infect garden or field peas, vetch,

216 and broad beans. And then the next group is Rhizobium phaseoli, which will infect garden or field beans. Then comes Rhizobium lupini, which will infect the lupines; and Rhizobium japonicum will infect the soy beans.

So here we have got six cross-inoculation groups. Practically each one of them has a number of various plants to which it is specific and the seeds of which it will infect.

The Court: Yes. All right, we will take a short recess.

217 (Whereupon a short recess was taken.)

Mr. Thiess: Q. Now, Mr. Bond, have you another photograph that you can produce, which shows these effects?

A. I have a photograph of three groups of soy bean plants, eight plants in each group.

Mr. Thiess: I would like to have this photograph marked for identification as Plaintiff's Exhibit Number 15.

(Said photograph was thereupon marked as Plaintiff's Exhibit No. 15 for identification.)

Mr. Thiess: Q. Now, will you describe what that photograph shows?

A. The photograph is of soybean plants, three groups of soybean plants, with eight plants in each group.

The first group are plants obtained from a pot, to which no bacteria were added. It is an uninoculated control, one of the uninoculated control products.

The second group was inoculated with strains 95 and 96, unmixed with any other bacteria.

The third group was inoculated with the same strains 95 and 96, mixed with other species.

The other species were alfalfa and clover. In this
218 case there is no real difference—there is no real apparent difference between the two groups of plants, that is, the groups on the far right, the leaves are bunched up a little and it does look a little smaller, but there is no appreciable obvious difference there; the height of the plants are approximately the same, but on an analysis, by means of the efficiency test as shown in Exhibit 5, there was a substantial reduction in yield in the third group.

These pictures show that even though there may be a 20 per cent difference in the growth of the plants, visual observation is a very inaccurate method of determining this difference.

The only way the difference can be detected with any assurance of accuracy is to conduct an efficiency test and actually analyze the plants for their dry weights and for their milligrams of nitrogen contained in those plants.

Mr. Thiess: I would now like to offer in evidence, if Your Honor please, Plaintiff's Exhibits 14 and 15, which have been marked for identification.

The Court: They may be received in evidence.

219 (The photograph headed "Clover" and showing in the upper right hand corner thereof "40 PLANTS EACH GROUP", so offered and received in evidence, was marked Plaintiff's Exhibit No. 14.)

(The photograph headed "SOY BEANS, 8 PLANTS EACH GROUP", so offered and received in evidence, was marked as Plaintiff's Exhibit No. 15.)

Mr. Thiess: I now wish to refer you again to the chart which has been offered in evidence as Plaintiff's

Exhibit 10, Effect of Inhibition in Mixed Culture, which you started to describe yesterday and which we did not complete, and I wish you would start right at the beginning and describe what that exhibit shows.

A. Figure 1 represents greenhouse pot test of an inhibitive strain of bacteria.

The vertical columns represent the total amount of nitrogen found in plants, uninoculated plants, plants inoculated with the single culture, that is, strains unmixed with any other species.

The third column represents this same strain, mixed with other species of bacteria.

This inhibited strain showed a loss, due to inhibition indicated by the difference between the single and the mixed columns.

Translating that into field results, Figure 3 shows
220 a typical number of bales of hay that would be obtained through the use of a culture containing these same inhibitive strains. When used alone, it produced a good yield. When used in mixture, there was a definite loss due to this inhibition.

Figure 2 shows greenhouse results obtained as a noninhibitive strain of bacteria when used single and when used mixed.

The first column again represents a total nitrogen found in uninoculated control.

The second column represents a total nitrogen found when the noninhibitive strains are used alone.

The third column shows the total amount of nitrogen found when these same noninhibitive strains were mixed with other strains. In this case, no loss was observed, due to the mixing, due to the association of this culture with the other species.

Translating this into field results, we have Figure 4, which shows that there is no loss—there is no difference in using these noninhibitive strains in single culture or in mixed culture.

These results are merely typical. They are not taken
from any definite data. It shows a typical result
221 obtained with inhibitive strains or with noninhibitive strains.

Mr. Thiess: Q. I now wish to call your attention to a drawing that you made, showing the reduction in yield in red clover due to inhibition, and I would like to have

this drawing marked for identification as Plaintiff's Exhibit Number 16.

(Said chart entitled "Reduction in Yield of Red Clover Due to Inhibition" was thereupon marked Plaintiff's Exhibit Number 16 for identification.)

Mr. Thiess: Q. (Continuing) Now, will you describe what this drawing illustrates?

A. These two charts illustrate the differences due to the inhibition, taken from actual experimental data.

The chart on the left hand side is taken from data from our own tests, and the single clover culture—strains of clover used alone yielded 8.93 grams dry weight over the uninoculated controls.

These same strains of clover, when mixed with alfalfa and soybeans, yielded only 7.30 grams, increased 222 grams dry weight over the uninoculated controls.

There is a 18.2 per cent loss here due to the inhibitive effect of the alfalfa and soybean bacteria on the clover organisms.

The chart on the right hand side illustrates actual data taken from Max Kronberger's paper which was previously introduced.

The first column showed an increase of 9.26 grams dry weight over the uninoculated controls.

The second column showed an increase, which was inoculated with the same clover strain, mixed with alfalfa bacteria, showing an increase of 6.96 grams dry weight over the uninoculated controls.

In this case, 24.8 per cent loss was obtained due to inhibition, that is, inhibition of the alfalfa organisms in the culture.

The Court: Q. Does the 18.2 per cent loss in your own experiment indicate that it is not desirable to use that combination?

A. No. If these clover strains were used in a mixed inoculant, with alfalfa and soybeans, such as you have here on the table, that inoculant would not produce the yield that these same strains would have in a single 223 culture.

The Court: Q. I understand, but is that a sufficient percentage as to cause you not to use it?

A. Yes.

Mr. Thiess: I would like to offer this drawing as Plaintiff's Exhibit 16.

The Court: It may be received.

(Said paper showing two charts appearing under the general heading "Reduction in Yield of Red Clover Due to Inhibition", so offered and received in evidence, was marked as Plaintiff's Exhibit Number 16.)

The Witness: In explanation these are just the dry weight determinations. The percentage of nitrogen of the lower yield, that is of the mixed culture in this particular experiment, was less. So when it was based there, on the difference in the milligrams of the nitrogen, the protein content of the plant, there was a larger difference than just 18.2 per cent. This chart just indicated the dry weights.

Mr. Thiess: Q. Now, I have referred to this heretofore, but I would like to have Mr. Bond refer to the
224 patent, page 5, column 1, lines 36 to 38, at which point the patent refers to noninhibitive strains of the organisms by the term "alpha", and I wish you would please state in what manner this term alpha was used in your patent specification and claims.

A. Alpha is used to designate strains of root nodule bacteria. They are mutually non-inhibitive in a mixed culture. It is an arbitrary designation to simplify the reference to these noninhibitive strains.

Q. Then, whenever the term alpha is used to modify a species of bacteria, in your patent, it refers to a mutually noninhibitive strain, is that correct?

A. That is correct.

The Court: Q. That is something that you used, rather than something adopted by the trade?

A. Yes, that is right. The term alpha, in its application here to the specification—

The Court: Is your own?

A. (Continuing:) —is my own designation. It is not necessarily accepted by the field. As I understand it, it is a common practice in patents of a bacteriological nature to assign terminology of this nature to certain types of organisms that are being discussed in the patent, whether it deals with root nodule bacteria or
225 deals with bacteria of other kinds.

Mr. Thiess: In other words, the patentee is making his own dictionary.

The Court: Yes.

Mr. Thiess: Q. Now, merely so that we may have it for the record, will you refer to the patent, page 5, column 2, beginning at line 32 and the matter that follows; does that describe the manner in which the mixed inoculant is prepared?

A. Yes, from line 32 down through line 72 is a description of a method for preparing a mixed culture.

Q. And that is the one that you referred to and is depicted in Plaintiff's Exhibit 7?

A. The Exhibit 7 does not demonstrate the method of making a mixed culture. It demonstrates a method of preparing bacteria suspension that can be used to make a mixed culture.

Mr. Thiess: That is it.

Q. Will you just briefly refer to the manner in which you make that, without going into it in too much detail, because it is all set out in the patent?

A. I would like to refer again to Exhibit 9— is 226 that correct?

Mr. Thiess: 7.

The Witness: 7? It is marked 9 on this.

Mr. Thiess: What have you there?

The Witness: The same one.

Mr. Thiess: Yes, that is 7.

The Witness: A. The start of the preparation of a mixed culture is the same as the start for the preparation of a single type culture which is demonstrated in this chart. The same steps are followed as with the test tube stock strain 1. Taking for example, a mixed group containing three different species, which will inoculate three different cross-inoculation groups, we start out with at least three different stock test tube strains, stock strains and test tubes, and each one of these is run through the same procedure down to the point where the bacterial suspension is obtained in container 6.

The Court: I thought you explained this yesterday?

Mr. Thiess: He did.

The Witness: I did, but I was just explaining that it was used in a mixed culture.

This is an illustration of a preparation of single 227 culture here, but it is identical in that point, except we make three different bacterial suspensions we get 3 6s in other words, and those three different containers containing three different suspensions are checked in the laboratory to predetermine the number of organisms pres-

ent in each, and a volume of each is calculated so that the organisms will be added to the mixer 8, in the proper proportion, and from there on it is simple—adding the different suspensions together in the mixture and thoroughly stirring the whole mass and discharging it over again into the drum 9, and ultimately it is packaged into the finished product 10. In other words, the same procedure is used except that there are three different cans of bacterial suspension 6, instead of just one, and they start out with three different stock strains 1.

Q. This mixer is something that you revolve?

A. It is a mechanical mixer that thoroughly incorporates the bacterial suspension into the humus.

Mr. Thiess: Q. Now, Mr. Bond, will you state, what are the advantages that flow from the use of a mixed culture of the type described in your patent, and I refer you particularly to your patent, page 2, column 2, beginning at line 8?

228 A. Beginning at line 8 is a discussion of the advantages of the composite inoculant over that of a single inoculant, from the point of distribution. These cultures are sold by the manufacturer to seed jobbers or distributors. They in turn sell the product to retail dealers, and the retail dealers in turn sell the product to the farmer.

Each container has an expiration date stamped on it, and after that expiration date, the cultures are returned, through that sequence, to the manufacturer; that is; any cultures that the dealer has left on hand are returned to the distributor, or any cultures that the distributor accumulates from the dealers or that he has on hand are returned again to the manufacturer.

Previous to the past few years, all manufacturers allowed 100 per cent on those returns, that is, they were replaced the following year without charge, to insure the dealers having only fresh cultures.

In the last few years, restrictions have been imposed on that, in that only 50 per cent is now allowed to the dealer and to the distributor down to the manufacturer.

229 But the important correlation is this: With separate packages for each different culture and each of these packages being offered in several sizes, there is an accumulation of stock that is very difficult to follow through on, that is, is very easy for a dealer to get stuck,

we will say, at the end of the season, with too much alfalfa inoculation or too much red clover inoculation, and, he ordered enough, to the best of his knowledge, to supply his demand for that particular season, and if the season was unsuitable for planting at the proper time, maybe the amount of seed in this particular territory that year planted would be reduced and he would be left with a lot of surplus on hand.

By combining the culture, by combining alfalfa with clover, they were able to carry a smaller stock and still be able to supply an ample amount of inoculation for either clover or alfalfa. It was better exemplified by the use of a container containing three different units. It reduced the amount of stock that each of them had to handle and the different types of stocks. The seed inoculants are a side line to the seed trade proper and it does produce difficulties in trying to keep track of all these different sizes and all the different cultures,
230 and any simplification along those lines has very distinct value.

The Court: Q. Is the product returned to the manufacturer re-used?

A. Product returned to the manufacturer is destroyed.

Mr. Thiess: Q. Prior to the time of your invention, did the Kalo Inoculant Company sell single cultures for each of the plants, clover and alfalfa?

A. Yes.

Q. And since your invention, have you sold these single cultures, or at the present time do you?

A. No. We do not offer the single cultures at the present time, because we have no demand for them.

Mr. Greer: Because of what? I did not get that last part.

The Witness: We have no demand for the culture—for the single, individual cultures, that is for clover and alfalfa.

Mr. Thiess: That is it.

The Witness: We do have a demand for soybeans, Austrian winter peas and some of the other cultures.

Mr. Thiess: Q. But you also have a demand for the mixed cultures of soybean, alfalfa and clover cultures?

231 A. That is true.

Q. Now, in your patent, page 1, line 12, you refer to "symbiotic relationship." Will you please state what is meant by that?

A. A symbiotic relationship is a mutually beneficial relationship and in this particular case—

Mr. Thiess: Just a minute. Your Honor, commencing in line 10, the patentee says, "but it has been known for a number of years that it can only be carried out when the plant grows in symbiotic relationship with certain bacteria of the genus Rhizobia."

Now, I am asking him to define what symbiotic means. Now, Mr. Bond, start over again.

A. Symbiotic relationship is a mutually beneficial relationship. In this case, the plant supplies the bacteria with a home and food to grow on, and in turn the bacteria supplies the plant with fixed nitrogen compound.

Mr. Thiess: Q. Now, referring to your patent, page 2, the second paragraph, column 1— I will change that. It is the first complete paragraph, where you refer to the term "viable strains." You say, "These cultures have appeared in a large variety of forms and contain
232 a large number of viable strains of the desired organism." What do you mean by the term "viable strains"?

A. Viable strains are living strains.

Q. Now, on page 3, column 1, line 61 of your patent, you refer to "aerobic" and you say, "may readily develop under aerobic conditions. What is meant by that?

A. Aerobic means in the presence of air. The Rhizobia require air for their multiplication of growth.

Q. Now, in your patent, on page 2, beginning at line 25, column 2, you refer to "pasture mixtures". Will you kindly tell us what is meant by this expression?

A. A "pasture mixture" of seeds is one that comprises a mixture of seeds including different species of leguminous plants and non-leguminous grasses. In the past, where one of these "pasture mixtures" contained seeds from two or more cross-inoculation groups, it was necessary for the farmer to buy two packages of inoculations if he wanted to inoculate that group, that is, if it contained, for example, clover and alfalfa seeds, in this "pasture mixture", you would have to buy a can of clover and a can of alfalfa inoculant, if he wanted to inoculate that mixture. The use of a composite culture would eliminate that need and he would only have to
233 purchase one package, to inoculate his "pasture mixture". This is a minor point so far as the ad-

vantages of composite cultures are concerned, that is, pasture mixtures are not widely used, but still it is a fact that it is one of the advantages of a composite culture.

The Court: Q. That would only be an efficient mixture with respect to the leguminous plants?

A. It would if there are two or more groups. It won't hurt if the grasses are in it, it won't hurt the grass seed, but it won't benefit the grass seed either, but, if in that mixture there were in addition to the grasses two or more groups of alfalfa or of different seeds that represent different cross-inoculation groups, it would be necessary to either employ two single cultures or one composite culture.

Mr. Thiess: Q. Now, referring to the method of preparing the inoculant described on page 3, column 1, line 14 of your patent, was that the common practice well known in the art of bacteriology, at the time you filed your patent application?

A. Yes. This practice was well known.

Q. Now, in your patent, at page 4, column 1, beginning at line 29, you refer to the "Petroff-Hausser bac-
234 terial counter or other suitable direct counting apparatus." To what extent is such a counter used and what is its degree of accuracy in this art? First, you might say what it is used for, and then answer the other.

A. The Petroff-Hausser counter is used to estimate the number of organisms in a liquid suspension and the counter proper is similar to a haemocytometer, that is, a blood counting chamber that is commonly used in medicine and it is used under a microscope and to actually count the number of organisms in squares of liquid. The accuracy of the counter varies with the operator and to the extent of the number of squares that are being counted and the number of samples that are being taken, but it can be used within a 10 per cent accuracy.

Q. Is this count quite similar to the manner in which they count the corpuscles in blood?

A. Yes. It is the very same.

Q. And substantially just as accurate, is it?

A. Yes, it is. It is a smaller counter. It is made with greater precision and has to be used under a higher magnification of the microscope. The bacteria are much smaller than the blood cells.

Q. Now, the defendant in reply to our Requests for
235 Admissions admitted that legume inoculants are applied to legume seeds prior to planting, as you have testified, but the defendant qualified this admission by stating "that the legume inoculants may be applied to the soil as well as to the seeds." What have you to say about this qualifying statement?

A. It could be applied to the soil, but it would be a very unreasonable procedure and I don't believe any of the legume inoculants are applied in that manner. You would have a problem of applying a can of inoculant of that size, which is sufficient for one bushel of clover or alfalfa, and one bushel of clover or alfalfa normally plants between four and five acres, and the cans contain about six ounces each. To spread six ounces over four or five acres with a can of this size, is a very improbable procedure.

Q. Now, in response to our Requests that the defendant admit that immediately thereafter "root nodule bacteria specific to one cross-inoculation group will not inoculate the leguminous plants of a different cross-inoculation group" defendant stated that it could not agree with the statement, and that "a strain or variety of root nodule bacteria may occasionally under ordinary conditions and frequently under special conditions produce
236 nodules on plants different from those it usually inoculates, or it may lose the ability to produce nodules altogether. So little is known as to the exact causes of nodule formation and so many unknown reactions occur it cannot be positively stated that root nodule bacteria specific to one cross-inoculation group will not inoculate the leguminous plants of a different cross-inoculation group under all circumstances." What have you to say as to that statement?

A. The statement is correct insofar as it says "under all circumstances." There has been extensive work done in recent years that indicates cross-inoculation in wild leguminous plants. Bacteria isolated from the wild legumes are to a certain amount capable of this cross-inoculation between cross-inoculation groups. But with the cultivated leguminous plants, to which inoculation is being applied, there are very few examples of exceptions to the rule. It is true of any biological phenomenae so far as cross-inoculating— By that they mean that alfalfa legume bacteria might cross-inoculate with red clover plants

or soybean plants, and there is evidence in the literature that occasionally such a thing might take place, but the whole foundation of the inoculant business is based
237 on the different species which are used for different plants. There would be no point in offering a culture for soybeans and another one for peas, if we could use the same one for all of them.

Q. Now, in response to request that the defendant admit the truth of the statement "that there is a variation between strains of root nodule bacteria of the same species with regard to their nitrogen fixing efficiency or their ability to benefit the host plant for which they are specific", defendant says "there are all degrees of variation from high or best nitrogen fixing strains, medium or good strains or low and poor nitrogen fixing strains but this nitrogen fixing characteristic is not constant as to any strain. In other words, one strain at one time may possess the highest or best nitrogen fixing characteristic but on the next application may drop to the lowest or may lose its nitrogen fixing characteristic altogether and then after a lapse of time may repossess such characteristic." What have you to say as to the practical importance of the matter contained in that quotation?

A. Well, again, the whole foundation of the legume inoculant business is based on the selection of highly efficient, good strains, and under proper conditions
238 they can be maintained, their level of efficiency can be maintained.

It is true that occasionally, again, an odd strain will apparently change, for no good reason, but the frequency of such an occurrence is very small.

Now, it is also true that the nitrogen fixing ability of these strains can be altered deliberately by special treatment, that is, they are altered by what is known as plant passage, by inoculating a plant forming nodules on it and separating the bacteria from those nodules and comparing it with the original culture. That culture may be changed with respect to its nitrogen fixing characteristic. It may be changed down or it may be changed up. The efficiency of the bacteria—the nitrogen fixing characteristic of the bacteria—will be affected just as it may be affected when two types of species are mixed together.

There are other examples that may affect this nitrogen characteristic—that may change this nitrogen fixing characteristic of the organisms. The addition of glycine, one

of the components of gelatin, reduces the efficiency of the bacteria.

239 In the presence of hydrogen, the efficiency of the bacteria is reduced, or in the presence of carbon monoxide, the efficiency of the plant bacteria complex is reduced; and there are other examples I find from the literature.

It is true that this nitrogen fixing characteristic can be changed, but it is also true that experiences have shown that strains can be maintained over periods of 20 years or more. With an artificial media of the proper composition, the strains will maintain their high efficiency and can be used with confidence in the preparation of commercial cultures.

240 Q. Mr. Bond, in your opinion as an expert in this art, in order to assure or insure against inhibition when mixing the strains of various species of bacteria when used for legumes, is it necessary to select a strain that is not inhibited if you want to be positive that the ultimate culture will give the maximum efficient result?

A. The only way one can be sure the finished culture will produce maximum results is to test the individual strains in the mixture against themselves; that is, compare the results obtained with each strain with the same strains in the mixture.

Q. Do you believe as an expert in this art that one can select efficient strains of bacteria for alfalfa and clover at random and mix them in a composite culture and be sure that the composite culture would not produce inhibition between the two strains of bacteria?

A. Well, there would be no way of being sure that random selection of strains, that there would be no inhibitive strains in the mixture. By accident non-inhibitive strains, which we have demonstrated do exist, might be selected but there would be no way of knowing until the culture had been tested by means of an efficiency test.

Q. Now, were there any other problems aside from the matter of inhibition involved in the production of a

241 satisfactory mixed culture for field legumes?

A. Well, evidence from the literature indicated that there was a second problem involved, namely, the presence of sufficient organisms of the proper type to form an ample number of nodules in the respective host plants for which the culture is to be recommended.

Q. And how did you solve that problem? And here I refer you particularly to your patent, Page 4, Column 1, beginning at Line 25.

A. Beginning at Line 25 there is a discussion of the method of predetermining the number of bacteria to be added to the mixed culture and, previous to that, the specification discloses a method of preparing the culture in such a way there would be a minimum amount of nutrient materials added to the final product.

Q. And what is the number of organisms that are contained in this culture prior to the time it is mixed with the humus or carrying agent?

A. Well, sufficient organisms are added in the first place that subsequent growth in the humus is unnecessary; that is, there are sufficient organisms in the culture and mixed with the humus to thoroughly inoculate the seeds without any subsequent growth.

242 Q. Will you now please sum up the various factors involved in the production of a satisfactory mixed culture for field legumes and the manner in which your patent insures such satisfactory mixed culture?

A. Well, there were two problems to be met in the preparation of the satisfactory mixed culture. The first was the preparation of the culture in such a way that sufficient bacteria would be present at any time within the limits of the expiration date on the container to form an ample number of nodules on the roots of the different host plants for which it was employed.

The second problem was the use of strains of different species that would not be inhibited when mixed together. In other words, the culture must contain only good efficient strains to produce maximum beneficial results when used under field conditions.

The Bond patent discloses a product which satisfies both these demands, both these problems. The first problem is solved by using a large number of organisms of substantially the same order of magnitude in a base containing a minimum amount of the nutrients to retard subsequent growth in that base.

The second problem was met by testing the strains
243 singly and mixed to be sure no inhibition would take place when these strains were mixed together.

Q. Can you state why you keep the nutrients in this medium down to a minimum?

A. The multiplication rates or growth rates varies

between different species and even between strains of the same species and, after the addition of the bacteria to the culture, to the humus, there is a following growth in spite of the fact that a minimum amount of nutrients is used and in that culture period, if one organism has a substantially higher rate of growth over the other, it would predominate over the other and the second strain would not be there in sufficient numbers after storage to thoroughly do the job it is supposed to do.

The nutrients also affect the life of the organisms in this manner. It is a common precept of bacteriology that accelerated growth usually indicates an accelerated death rate. In other words, if they burn the candle at both ends, they are used up in a shorter period of time.

Mr. Thiess: That is all. Take the witness.

244 *Cross-Examination by Mr. Greer.*

Q. Mr. Bond, let's go back a little bit to the beginning of your testimony. I would like to know, first, exactly what your age is.

A. My age?

Q. Yes.

A. I am thirty-three.

Q. And, as I understood you in your direct examination, your educational experience in connection with this art of bacteria pathology or bacteriology was that you graduated or obtained a Bachelor of Science degree, was it—

A. Yes.

Q. (Continuing) —at the University of Wisconsin and then later a Master's degree at the University of Wisconsin?

A. Yes.

Q. And what years were those degrees conferred upon you?

A. The Bachelor of Science degree in February 1934 and the Master of Science degree in June 1936.

Q. 1936. Now, immediately after that you went to the Earp Thomas Laboratories, Incorporated, and were employed there for a while, were you not?

245 A. No, I was never employed by Earp-Thomas.

Q. But you were there?

A. I was in the Earp-Thomas Laboratory, that is correct.

Q. What were you doing there?

A. I was trying to find Doctor Earp-Thomas most of the time. The Kalo Inoculant Company had been purchasing cultures from Doctor Earp-Thomas on a wholesale basis, mixing and packaging it at Quincy.

Q. He was engaged in the business of selling?

A. He was engaged in the manufacture. At the time I came with the Kalo Inoculant Company they wanted me to contact Doctor Earp-Thomas and, if he had any ideas of value on how to make a better culture, they wanted me to discuss the matter with him, if he had any better ideas.

It took me two weeks to find him and he had the worst laboratory I have ever been in and he had nothing to contribute at all. I think his product substantiates that, both on the product the Kalo purchased from him and his own product.

Q. The Kalo Inoculant Company did have a contract with him, did they not?

A. That is right.

Q. For using his cultures?

246 A. That is correct.

Q. The Kalo Inoculant was the exclusive distributing agent for the Earp-Thomas Laboratories' cultures, were they not?

A. Yes. I don't recall for what period of time that was in effect. When I came with the Kalo Inoculant Company I did not use any of his cultures or any of his methods.

Q. Was that contract in existence at that time?

A. Yes, it was in existence.

Q. How long, approximately, did it continue after you came with the Kalo Company?

A. I don't know how long but we used none of his cultures but used solely Humogerm, the trade name Humogerm.

Q. Did you use the trade name Farmogerm also?

A. Not after I came with the company. Previous to the time I came with the Kalo Inoculant Company I am not familiar with the cultures they used or the plant materials but to the best of my knowledge the Kalo Inoculant Company never sold any Farmogerm.

Q. Were you familiar at all with their advertising matter at the time you came there or shortly after you came there?

A. Not with respect to Farmogerm. I was with regard to Humogerm. They were not selling Farmogerm at the time I entered their employ.

247 Q. The Kalo Inoculant Company wasn't?

A. The Kalo Inoculant Company wasn't.

Q. Do you know whether or not the Thomas Company was selling it?

A. I do not know at that time.

Q. You know back in 1933 and 1934 that there had been on the market this composite culture that was sold under the trade name of All Crop Farmogerm?

A. That is right. There were several all crop cultures on the market previous to that time.

Q. Well, the Earp-Thomas Laboratories had the trade name of All Crop Farmogerm they used, did they not?

A. Yes, I knew that.

Q. Did you ever see any of those cultures?

A. No, I never saw one.

Q. But that was long before 1938 you knew it had been on the market?

A. I knew it had been on the market, yes.

Q. Well, now, that was when, when your were with the Earp-Thomas Laboratories? That is when you were there doing this research work?

Mr. Neuman: You are misstating the witness' testimony. He did not state that.

248 The Witness: I was trying to find Doctor Earp-Thomas most of the time.

Mr. Greer: Q. What were you doing the other time?

A. I enjoyed New York City and finally traced him down to Boston. I located him at his hotel there. He was supervising a garbage disposal plant and a fish waste plant and I had the opportunity to talk to Doctor Earp-Thomas at that time and, so far as any valuable information with respect to inoculants at that time, there was absolutely nothing to learn.

Q. Did you see any inoculants being prepared at all in his laboratory there?

A. I was in his laboratory and they were preparing a milk culture that was supposed to cure everything from cancer to hives. They did have some legume culture in bottles. The only way they prepared it was to transfer it from a test tube to an agar slant, a procedure familiar to anyone in the art. So far as learning anything, I did

not see a thing there. I believe I could substantiate that from other people who have been in his laboratory.

Q. Then after that you were employed by the Agricultural Laboratories, Incorporated, were you not?

A. I was employed by the Agricultural Laboratories, Incorporated? Well, let's see. I don't know whether
249 you would call it employed by them or not. I had agreed to work with the Agricultural Laboratories, Incorporated.

Q. You had what?

A. Agreed to work with them and I had accepted an expense check from them. That is the extent I worked for the Agricultural Laboratories.

Q. You were not paid a salary at all?

A. I was paid no salary whatever.

Q. How long was the trip?

A. The trip amounted to a few days.

Q. How long?

A. A few days.

Q. What was the purpose of it? What did you do?

A. The Agricultural Laboratories were interested in employing me at that time and after that summer they introdnced this mixed inoculant. At the time I was discussing things with them I hadn't any idea they were interested in a mixed inoculant.

Q. You were there only two days?

A. I don't recall the exact number of days. It was four years ago and I may have been there longer or shorter. Whatever it was, I was just discussing things
250 with Mr. Elmer. There was no research work or anything else.

Q. That was in 1941?

A. That was in 1941.

Q. At that time then you were enjoying your regular salary from the Kalo Inoculant Company?

A. That is correct.

Q. You were their employe when you went down to the Agricultural Laboratories?

A. That is correct.

Q. Now, let's get into this bacteria field for a little while. As I understand the technical terms, the general family of bacteria that is applicable to leguminous plants has this name Rhizobia.

A. The genus has the name Rhizobia.

Q. I said the general family; that is the same thing as genus?

A. The genus comes under another family biologically.

Q. And it is a form of life that is called bacteria?

A. That is correct.

Q. And nature provides that life?

A. That is correct.

Q. And that bacteria or life which is found in na-
251 ture, as stated in your patent at Line 43, I believe it is, that I am quoting—

A. What page?

Q. Beginning at Line 43 on Page 1.

Mr. Thiess: What column?

Mr. Greer: Column 1.

Q. (Continuing) —where you state:

"Bacteria of the genus Rhizobia which are capable of infecting leguminous plants so that nitrogen may be fixed are widely spread in nature."

Now, that is a universally accepted fact among scientists, is it not?

A. That is correct.

Q. Now, you also say in that same column on the same page beginning at Line 9 that

"The mechanism of this nitrogen fixation is not understood at the present time, but it has been known for a number of years that it can only be carried out when the plant grows in symbiotic relationship with certain bacteria of the genus Rhizobia."

That, likewise, is an accepted fact among scientists,
252 is it not?

In other words, my point is this, that the Rhizobia of itself, that is this bacteria, in and of itself does not fix any nitrogen or take any nitrogen from the air. It has to be in association with the roots of a leguminous plant. There has to be that corroborative action between the two, the Rhizobia and the roots of the plant, is that correct?

A. That is correct.

Q. And that is what you mean by symbiotic relationship?

A. Yes.

Q. If the bacteria does not have this affiliation with the fibrous condition of the roots of the plant it is not symbiotic. If it does have it, there is a symbiotic relationship, is that correct?

A. That is correct.

Q. And the bacteria in order to function at all in this nitrogen fixation characteristic must enter the fibers of those roots?

A. That is correct.

Q. Now, would you take the position that this fibrous condition—maybe I am not using the technical language but I think you understand what I mean—that the fibrous condition of the roots of leguminous plants is not
253 always the same, even in the same species of plant?

A. You mean by the composition of the roots?

Q. Well, you might call it chemical composition or—I will put it this way: One bacteria, which we will regard as just one little bug, for instance,—

A. Yes.

Q. (Continuing) —may be able to do it in the fibrous condition of one root of, we will say, an alfalfa plant, but another bacteria might not be, or we will say that the same bug or same condition might not be able to enter the root of another alfalfa plant?

A. Well, there is no direct correlation between the number of bacteria applied to the root and the number of nodules formed.

Q. Well, you will not have the nodule formation unless the bacteria gets into the root?

A. Correct.

Q. What I am trying to get at is, there is a relationship between this symbiotic relationship. You don't always get the same infection by using the same specie of bacteria with the same specie of plant?

A. There are physical conditions of environment that will affect either one or both.

254 Q. Well, that means then that about all we know about it, from the standpoint of actual knowledge, is that when you bring the two into relationship, the bacteria and the plant, sometimes you are going to have nodule formation and nitrogen absorption from the atmosphere which we will call nitrogen fixation, sometimes you are going to have it and sometimes you do not have it?

A. Under identical conditions with the same plant and the same strains of bacteria prepared in the same way, there is every confidence that if the nodules are obtained in one case you would get them in the second.

Q. Wouldn't the mere location of the pot on the shelf in the laboratory bring about a variation?

A. That is true. Then you don't have the same conditions. You may have less light. The physical environment can influence the production of the plant.

Q. Even if the pots are in the same room on the same shelf?

A. Planted with the same seed.

Q. The same kind of seed. It can't be the same seed.

A. With the same batch.

Q. Out of the same batch?

A. Yes.

255 Q. And you wouldn't necessarily get the same nitrogen fixation result. You might or you might not is all I am trying to get.

A. Well, there is an inherent variation that there is there, but to say you would not get nodules formed in one case and you would in the other, is a very extreme case; the probability is very small.

Q. You take, for instance, the color of the seed itself might have some influence?

A. Yes; there is a different variation between pots in a series, all of which have been presumably treated in the same way.

Q. And those variations or differences are brought about by nature. You don't know exactly why they happen; they just simply happen.

A. That is true and experimental errors are introduced by the operator, inadvertently.

Mr. Greer: Now, I would like to, for a moment, look at these two plants that you had in here yesterday. I think they are in the other part of the room. (Counsel produces two pots of plants.)

Q. (By Mr. Greer) We will assume that these two plants are in the same condition that they were in
256 yesterday. One of them seems to have wilted considerably more than the other one overnight. As I understood you, these are soybean plants?

A. Yes, sir.

Q. And the one which is of shorter growth was not inoculated with any bacteria at all?

A. That is right.

Q. And the one that has the greater growth and development was inoculated but you do not know whether it was inoculated with a single strain of japonicum, or soybean bacteria, or a mixture, as I understood your testimony yesterday.

A. Yes; that is because I haven't checked the number. I can go back to the laboratory and tell you what it was inoculated with. It is number 12-4.

Q. It doesn't make any difference. You can't tell from looking at it.

A. I can't tell from the plant what was added to it but I can tell from my records what was added to it.

Q. It was inoculated with either a single strain or a mixed strain.

A. I believe this was single strain. The last ex-
257 periment was almost all single strains.

Q. My point is: You can, from just visually looking at it,—I think I can, and I am not posing to be an expert or one skilled in this art,—you can, from a visual examination of a comparison of these plants, tell that the plant which is inoculated, is tremendously benefited over the plant which was not inoculated.

A. Yes; in this case there is no question about it.

Q. As a matter of fact, you could approximate the percentage of nitrogen fixation, couldn't you? I don't mean that you would be exactly accurate in it but one skilled in the art, from just a visual examination of two plants in comparison, could make a pretty good guess as to the extent of the nitrogen fixation?

A. You could make a pretty good guess within approximately 20% to 25%. When you narrow down your percentage less than that, it is very difficult even for an experienced man, to detect differences, for sometimes they are greater than at others.

In the literature there are observations that when compared with actual amounts statistically, indicate that visual examination would give us an approximate estimate.

Q. That would be reliable to act on for commercial
258 purposes?

A. Yes.

Q. You could not determine, of course, the exact amount without going through this chemical analysis—

A. That is right.

Q. —and this statistical analysis, and all that. That would give you the exact amount of the difference; that is correct, isn't it?

A. That is correct; that is, within the limits of your experiment.

Q. That applies, then, to these two plants in which

you can visually, just by the eye, as you are skilled in the art, or even one unskilled in the art, could tell that that is a growth and development of the inoculated plant beneficial over the uninoculated plant?

A. That is correct.

Q. That means that there was greater nitrogen fixation in this inoculated plant than there was in the uninoculated one, is that right?

A. That is right.

Q. Now, that same thing would apply, would it not, Mr. Bond, with regard to a comparison between a single strain inoculation and a mixed strain inoculation; we will
259 say, for instance, that there is a difference in the appearance and that would be the case, would it not, either beneficial or deleterious?

A. Or deleterious.

Q. You could tell that by just visual examination?

A. You could tell it if it ran over 20% to 40%. If the difference was less, if it was within a smaller range, you might not detect that difference.

In a 20% difference in fields, with the millions of acres of beans, for example, which are inoculated with inoculation, it would make a very substantial difference in the ultimate yield.

That is, you may have two pots like that sitting side by side, and you look at them and you say they look about the same to me.

It is like this photograph we have here, of soybeans. There is a 20% difference here and looking at it, it is rather hard to find it. One is bunched up more than the other and is apparently smaller.

Q. Which exhibit are you looking at, Exhibit 15?

A. Yes.

Q. Wouldn't you say that that middle one which was the unmixed inoculation, showed a little better, I don't mean any appreciable—it shows a little better?

260 A. It looks a little better but here is also a problem involved here. This was one pot out of a series of five, I believe it was in this experiment, and you would have to sit there and compare each pot and you see those things varying up and down between each pot and to end up and to estimate that the average of five pots is better than the average of the other five pots, is a very difficult thing to do with any accuracy.

Q. But looking at every pot you can tell just by looks,

as you said yourself, and tell the variations between the pots themselves?

A. I don't believe that this picture here shows much variation between the pots.

Q. But it does show a variation?

A. The variation is very small.

Q. But it does show a variation, does it not?

A. It shows a very small variation, if any. It depends upon how you look at it. The plants on the far right are even higher than those in the center. The leaves are fluffed out more on the center ones, but the leaves are bunched up on the ones to the far right.

Q. That is a variation, isn't it?

A. It depends on how you detect it. If you said
261 that one on the right looks higher than the one on the left, and maybe there is more in it. I don't think this picture shows any distinct difference between those two.

Q. You won't say that it shows even a slight variation?

A. I would say the one on the right is slightly higher than the one on the left and the one on the left seems to have a little wider spread on it than the one on the right.

Q. If that difference is wider than that you could tell it by visual examination?

A. In some cases.

Q. Even without dry or wet weight comparisons?

A. Yes, in some cases you can. In other cases apparently plants are identical and on an analysis, particularly as far as the nitrogen is concerned, there is a very substantial difference between the yields.

Q. Now, in conducting laboratory experiments to determine this matter of the extent of nitrogen fixation by this relationship between bacteria and the host plant one thing that is necessary to be done in order to obtain a reliable result from your test is you place the soil in pots do you,—something like that?

A. Yes; those pots we use to grow them in.

262 Q. You plant the soil you want the seed of the plant to grow in in these pots?

A. Yes.

Q. And you sterilize the soil to get it free of any bacteria that would produce a deleterious effect on the growth of the seed you intend to put in it?

A. And the sand may contain nodule bacteria in it. You want no nodule bacteria in it.

Q. You want as near a pure medium that you are going to use as possible, and as a consequence you sterilize the soil you put in the pots?

A. Yes.

Q. What is the standard recognized method among bacteriologists that was in existence, we will say, at the time of your application for your patent, in 1938? There was a standard method of sterilizing these pots in that kind of a laboratory test, was there not, or an accepted standard?

A. Yes, that is right; anywhere from an hour up to 12 hours under 15 pounds steam pressure.

Q. Will you speak a little louder?

A. Anywhere from an hour up to 12 hours under 15 pounds pressure, resulting in an adequate sterilization of the sand.

Q. You would put it cold into an autoclave?

263 A. Yes.

Q. That is a kind of an oven that you put these pots in and what was the atmospheric pressure?

A. One atmosphere, that is 15 pounds.

Q. 15 pounds of pressure, and at what temperature?

A. That amounts to around 123 degrees Centigrade.

Q. And you would leave it in there for how long?

A. Well, in sterilizing the pots I sterilize them for an hour. That kills any of the legume organisms present.

Q. You wouldn't feel safe that you had killed the contaminating bugs that are in there, under an hour?

A. Oh, as far as feeling safe about it is concerned, all that is necessary is to heat it above 60 degrees Centigrade for ten minutes, and all the legume organisms will be killed.

There is a factor of penetration of the sand by the heat, and just as a safety precaution they are sterilized at a higher temperature over a longer period of time.

Q. You wouldn't get your higher penetration of the soil under this ten minutes. That is why you leave it in for an hour and sterilize the entire contents of the pot; not only the outside of it and the rim on the inside, but to get in the sand in the middle part?

264 A. The sand is sterilized by this standard method.

Q. And the accepted method was that you would leave it in there approximately an hour's time?

A. That is correct.

Q. In addition to this, your next step is the sterilization of the seed that you are going to test, is it not?

A. Yes.

Q. You don't take the raw seed and dump it in this soil?

A. No; the seed is sterilized by the accepted, standard method.

Q. What was, in 1938 the standard accepted method in the United States among bacteriologists and scientists and those skilled in this field—the accepted standard methods of sterilizing the seed you were using?

A. Different methods were used. The particular method that I used was a wetting of the seeds with alcohol and then soaking in 1% chlorine solution for 15 minutes.

Q. And that is a pretty generally accepted standard method?

A. That is correct.

Q. If you used too strong a caustic solution or something of that kind or left it there too long, you would injure the seed, would you not?

265 A. Yes.

Q. And that would have a deleterious effect on their germination in your test?

A. Yes.

Mr. Greer: May I look at chart, Exhibit 5? (Counsel hands Mr. Greer the exhibit.)

Q. (By Mr. Greer). Maybe it won't be necessary to go into this, in view of what my notes show you have stated, in answer to Mr. Thiess' question to you on direct examination, so I will ask you if I am correct in my impression on that: In the method of culture which is set forth in your patent in the culture of the single strain of bacteria, whether it is an alfalfa strain or a soybean or clover strain, you take the pure bacteria or strain of bacteria from what nature provides, as you said, scattered around here, and you isolated that, and then you put this through this method of cultivation for the purpose of multiplying the colony of the bacteria so that you can have a stock culture from which you can draw in selling it to your customers, and things of that kind, is that correct?

A. That is correct.

Q. And this method of the separate cultivation of these

strains that is set forth in your patent, as I under-
266 stood you to say, that method was one that was well-known in the art at the time of your application for your patent, in 1938?

A. Yes, essentially. There are some slight variations that are described in the specifications that I don't recall seeing before.

Q. Those variations would not, in any way, affect the character of the bacteria?

A. No; that is correct.

Q. When you get through with your culture you have the same bacteria you got from nature, but you have more of it, is that correct?

A. That is true; that is correct.

Q. And that was well-known in the art among those skilled in the art, prior to the date of your application for your patent or your claimed invention?

A. Yes, sir.

Mr. Greer: That won't make necessary for me, then, to use chart 5 any further.

267 In the District Court of the United States.

* * (Civil Action—No. Q-62) * *

Q. Mr. Bond, at the hour of adjournment at the
268 noon recess we had gotten down in the separate cultivation of your single strain where you have got that cultivated. Then, as I understand it, the next step in your process is to test that strain for its efficiency in nitrogen fixation, as shown on your illustrated chart, No. 5.

A. Yes.

Q. Now, that test, which in this chart is entitled "Efficiency Test for Nitrogen Fixation", that was a routine standard test well known in the art before your claimed invention, wasn't it?

A. Yes, sir.

Q. Now, in conducting such a test this chart just shows one pot, and that was meant for illustrative purposes. You would not base a scientific test on just the growth of one pot of a flower, or pots, would you?

A. No, the plants must be done in replicate. There is no way to statistically analyze the result unless there is at least one replicate of the pot in each series.

Q. So that this is just meant as illustrative?
A. Yes.
Q. And in the real test you would have a series of pots?
269 A. That is correct.
Q. Three or four, at least, or in all probability five, to make a standard number, isn't it?
A. It varies with the setup of the experiment.
Q. What?
A. It varies with the type of setup in the experiment you make. If an analysis of variance is used to determine the difference between the plants, it is unnecessary to have as many replicates in each series as when you just compare one series with another by means of statistical treatment.
Q. Well, I am comparing now the efficiency—
A. Yes.
Q. —of this bacteria in nitrogen fixation, and you would use a plurality of pots.
A. A plurality, more than one.
Q. More than one. And one of the purposes for that is that even in two pots there might be a variance of some kind?
A. Oh, yes, there is always a certain amount of variance in the series.
Q. That is the point, a certain amount of variance. You don't know why, it just simply happens, even
270 using the same strain under the same circumstances.
A. Yes, sir.
Q. There is this variance. Therefore, in order to have an accurate scientific test, you take a plurality of pots and then you strike the average?
A. That is correct.
Q. And that gives you what you consider your result as to your efficiency test. Now, all that is done. Then if you want the mixed culture, that brings us down, doesn't it, to your bacteria being in the container marked No. 6 on your illustrative chart, Plaintiff's Exhibit No. 7?
A. Yes.
Q. You have got your bacteria in here and you have tested them. You have taken them out of there, or taken some of them out of there, and subjected them to this efficiency test.
A. Well, the efficiency test is conducted on the stock strain 1 that we start with.

Q. Yes?

A. It is not necessary to subject that same strain to an efficiency test every time the culture is manufactured.

271 Q. No, I understand that.

A. The bacteria in stock strain 1 are tested, but those in the container 6 are essentially the same organisms.

Q. Yes. Now, if you were going to make your composite culture, you then have gone through that culture singly, of a clover strain. We will say we are going to mix clover and alfalfa. Now, you have gone through that with the clover strain. Then you go through the same process with the alfalfa strain?

A. Yes, sir.

Q. And then you put both the alfalfa strain and the clover strain in this humus base?

A. That is correct, according to the diagram.

Q. Yes, and in doing that you follow the same process that you would if it were a single inoculant, except that you put the two in?

A. That is right.

Q. And that was standard practice, that method of putting the bacteria into the base, the carrying medium, that was standard practice at the time of your invention?

A. The method of putting it in the medium was
272 standard practice, but it was not necessarily standard practice that the same method of growing the organism was used all the way through, nor was it necessarily standard practice to determine the number of organisms and to put in a larger number to insure inoculation without depending on additional growth in the base. That was not necessarily followed out in the preparation of single cultures. They can be made that way or they could be made this way.

Q. I don't know as I follow you exactly on that.

A. The single cultures can be satisfactorily prepared in several different ways. Single cultures have been prepared that have been satisfactory when all they did was to take a heap of this humus, moistened it, added sugars and mineral salts and all sorts of nitrogenous material to it, and then inoculated that mass with a small number of bacteria, a small bottleful, and then continually stirred it over and left it incubate for a number of weeks, and they ended up with a good culture, usually

did. Sometimes contaminating organisms overgrew the others but it was one method of preparing a culture which in my opinion did not give a reliable result in the
273 preparation of a mixed culture.

Q. Well, what I was getting at was, your method of putting it in. I am not talking about the numbers you put in.

A. Yes.

Q. But your method of putting it in the carrying medium was a standard method.

A. Essentially the same.

Q. That you don't claim any invention of yours.

A. Oh, no, there was no invention.

Q. This carrying medium or base was a well known base, too, was it not?

A. Yes, the humus base was familiar to the art.

Q. That was known prior to your claimed invention in this patent?

A. Yes.

Q. Now, that humus base has some nutrient value in it, has it not, that the bugs can feed on?

A. The humus base does contain some amount of nutrients. However, the availability of those nutrients to legume organisms is a pretty uncertain thing. That is, the humus do contain, if I recall correct, the analysis, around two or three per cent nitrogen. Well, that
274 would seem to indicate that it was fairly rich in nitrogen. Yet this humus is not digestible as a feed. Sometimes it is used as a filler in feeds, and when it is so used the nitrogen container is of no value to animals. Now, animals are able to digest nitrogen compounds that the bacteria can't touch.

Q. Now, then, after these bacteria are in this container where they have been taken, where the solution is put in this container,—they are in a solution form there, are they not?

A. They are in suspension.

Q. Suspension form. And there is bacteria and nutrient matter in that solution suspension, too, isn't there?

A. There is. They are carried over from the media on which they originally grew.

Q. And that is what you put in the humus?

A. That goes into the humus.

Q. Now, do I understand you correctly, that when you have thus prepared this preparation, whether it is a

single culture or the combination culture by putting the two single cultures or more, if you want to, in the humus base, and we get this package here, which is the com-
275 bination culture, which you sell under the trade name of uni-culture,—do I understand that after it is then packaged that you no longer have any growth of the bacteria in there, any increase in its numbers at all?

A. No, the bacteria increase after they have been added to the humus.

Q. After it is packaged, that is?

A. After it is packaged. There is a subsequent growth.

Q. Well, then that means that there must be some nutrient material for them to feed on there?

A. Yes. Well, the legume organisms will grow on a very low nutrient medium.

Q. I did not understand that.

A. The legume bacteria will grow on a very low nutrient medium.

Q. Yes, but they won't grow unless there is some nutrient material there.

A. No, some nutrient material must be there.

Q. That is correct. Now, just one other point on that feature. Do I understand you to say in your direct examination that after you have once tested a strain, whether it be a clover strain or an alfalfa strain or
276 a soy bean strain of bacteria, and as a result of that test you find that it is a high nitrogen fixer,—do I understand your direct testimony to be that it remains constantly a high nitrogen fixer throughout a period of twenty years, we will say?

A. There are definite cultures that have been maintained for that period of time and have been frequently tested within that interval and have maintained their efficiency over that period.

Q. Well, aren't there also definite tests that other strains do not maintain that same consistency?

A. That is true, occasionally there is a strain found that is not constant. That is, its nitrogen fixing ability may drop. But strains of that nature is the exception rather than the rule.

Q. But there are such strains?

A. They do exist. When the strain is observed to vary in that manner, it is not used in making a commercial product.

Q. Now, I will ask you if you can tell us when this

business of artificial cultures had its origin in plant pathology, do you know?

277 A. It was about the turn of the century that artificial cultures were made and sold for the purpose intended.

Q. It was at the beginning of this century?

A. About at the beginning of the century.

Q. Well, will you go so far as to agree with me that in the beginning there was practically a unanimity of opinion among the scientists and those skilled in the art that there was only one strain of bacteria that was specific for all kinds of leguminous plants? Wasn't that the original thought of the scientists?

A. At one time, in the early history of the development of the culture of legume nodule bacteria, some investigators believed that there was one organism, but that has subsequently been disproven.

Q. Well, won't you agree that there is even now a school of thought among competent, reputable bacteriologists and scientists in this field that that original thought was correct? I am not asking you to state whether that is correct or not, but I am simply asking you to state if you don't know that there are these two schools of thought, one holding the single strain and the other holding the cross-inoculation strains.

278 A. To my knowledge there is no school of thought that holds that one species will cross-inoculate all the inoculation groups.

Q. Well, that is the majority of them. Is there a school of thought that holds that it is—

A. That is particularly true in the cultures isolated from some of the wild legume plants.

Q. You don't think it would be applicable to alfalfa and clover or alfalfa and soy beans or something like that?

A. Such crossing of the groups of inoculation is extremely rare in the case of clover, alfalfa and soy beans.

Q. And you deny that there is a school of thought maintained by any reputable scientists that there is the single strain that would be effective in those sort of groupings?

A. Such a strain may be found, but of the thousands of strains tested that is an extremely rare occurrence.

Q. I am not asking you as to the facts, I am simply asking you if you don't know that there is that school of thought among some reputable scientists.

A. That an organism may be isolated from clover
279 that will also form nodules on alfalfa and soy beans, is that the question?

Q. Yes. I am not asking you whether that is a fact or not, I am asking you whether that is a fact that there is a school of thought that holds that.

A. This school of thought may believe that such an organism may exist, but they also know that there are many of the organisms that belong to those groups that do not cross. The same school of thought, I am sure, will agree with me on that point.

Q. Well, then let's come back for a moment to your own artificial culture, and I am correct, am I not, in my interpretation of the statements in your patent that after you have gotten your separate cultures—

A. Excuse me, I believe I left—I couldn't find my data that I had up here and my patent is not there. I thought it was in my briefcase but I left it on the table. (Procuring data.)

Q. Now, coming back to Judge Briggle's thought, was my idea in connection with this question. After you have gotten your separate cultures of bacteria, then you have subjected them to a test as to their nitrogen fixing ability.

280 A. Not after; that is, we subject the strain that we start with to the test.

Q. All right, the strain.

A. But not in the commercial production of the product, there are no tests made for efficiency.

Q. It is a test of the strain itself?

A. The strain itself is tested.

Q. Separately?

A. Yes.

Q. And that is what you mean in claim No. 1, for instance, where you say, "An inoculant for leguminous plants comprising a plurality of selected cultures of different species", that word "selected" means that you have selected the individual strains that have a high nitrogen fixation value?

A. Going further, though, the cultures are also selected, "said cultures being substantially unaffected by each other in respect to their ability to fix nitrogen."

Q. I am coming to that later. I want now what you mean by the word "selected" there.

A. They were selected on that basis.

Q. On their basis first of nitrogen fixation value as separate cultures, that is your first selection?

281 A. Of course, there is no sense in trying to find—if the strain is non-inhibitive if it isn't even efficient—that is not what I mean here when I say "selected" in this claim 1.

Q. I am not speaking of inhibitive or non-inhibitive, I am taking the single strain.

A. Yes.

Q. And I am trying to find out what you mean by the word "selected" in the first part of this claim. Now, we will come to the inhibitive selection later on, I am taking now what you mean—you say "a plurality of selected cultures of different species of bacteria of the genus Rhizobium." That is one thought, and that selection—I am not barring you from your inhibition if you want to set that up later, but that thought and that selection is the selection of efficient strains for fixing nitrogen as separate strains, is it not?

A. That isn't a selection for efficiency in fixing nitrogen in the mixture.

Q. Let us turn, Mr. Bond,—if you want to be honest and fair with me in this matter, let us turn to page—

A. It is very clearly stated in the claim.

282 Q. —page 5 of your patent, on column 1, beginning at line 9:

> "Each of the strains are tested separately with its own host plant in order to select out those which are most effective in respect to the development of the host plant and the quantity of nitrogen fixed thereby."

A. I am sorry.

Q. Now, that is the selection that you referred to in claim 1 as being the selected cultures of different species of bacteria of the genus Rhizobium, is it not?

A. Wait a minute. I misunderstood you when you quoted the line and I did not find where you are stating. Was it line 9?

Q. Beginning with line 9 on column 1, page 5, where you are beginning to describe how you make your composite culture, and the first thing you do is to select the single cultures.

A. That is true, they are selected first, because there is no sense of even thinking of putting a culture in a

product that isn't good in the first place; so claim 1 would be first they selected a strain and tested it to determine whether there is any inhibition there.

283 Q. That is all right, you have selected your single strains.

A. Also selected the single strains to be put in the mixture, and that is what claim 1 refers to.

Q. You selected the single strains which you propose to put in your mixture?

A. Yes.

Q. Now, you don't know whether that is an alpha strain or a non-alpha strain at that time, do you?

A. No.

Q. And you don't know any way of determining whether it is an alpha strain or a non-alpha strain except by subjecting it to a routine test.

A. Yes.

Q. Now, by an alpha strain I mean a strain as defined in your specifications, as one which has no inhibitory affect or is not affected by association with some other strain.

A. Yes.

Q. That is what we mean in the terms of your patent when referring to an alpha strain.

A. Yes.

Q. And this test that you subject your selected

284 individual strains to, to determine whether they were alpha strains or not, was a routine, well known laboratory test.

A. Yes.

Q. The same as your efficiency test of a single strain, was it not?

A. Yes.

Q. You did not invent that test?

A. No, no.

Q. Now, you state in your patent that:

> "The cultures showing the best results in association with the host plant may then be selected and the various strains of the different species may be mixed together in order to determine if the nitrogen fixing ability of one species is adversely affected by the mere presence of another, as has been previously thought to be the case."

You then go on down and on line 38, in that same column 1, on page 5, you say:

"No method has been observed whereby the alpha strains of the organisms may be differentiated from the mutually inhibitive group of Rhizobia other than
285 by making actual nitrogen fixation tests by inoculating the various host plants with the proposed mixture of the Rhizobia."

That is a correct quotation from your patent, is it not, to the effect that there is no method that has been observed?

A. Yes.

Q. Therefore that means, does it not, that nothing that you have done to these bacteria brings about a state of inhibition or a state of non-inhibition.

A. No.

Q. That is simply, then, the work of nature, and you apply tests to observe whether or not that physical fact of nature is in existence in these Rhizobia or is not in existence?

A. Yes.

Q. That is correct. Now, this book that is entitled "Root Nodule Bacteria and Leguminous Plants", and is referred to as the University of Wisconsin studies in science, was published in 1932, was it not? Have you got a copy of that book with you?

A. I don't have it here.

286 (Book handed to the witness.)

Q. Did I say published in 1935?

A. 1932.

Q. 1932 is correct. Were you at the University of Wisconsin at that time?

A. I was attending school at the University of Wisconsin at that time.

Q. And I take it you were entirely familiar with this book?

A. I am not entirely familiar with each page in the book but I am familiar with the book, yes.

Q. Well, you knew of the book?

A. Oh, yes.

Q. And it was widely circulated among scientists and those skilled in this particula art, was it not?

A. Yes.

Q. The fact of the matter is, it is pretty generally regarded as the Bible in these root nodule bacteria and leguminous plant cultures in this country, is it not?

A. Yes.

Q. Now, did you consult this book at all when you went to the University of Wisconsin in 1937, to
287 ascertain the question of whether there was a different belief in inhibition or non-inhibition?

A. Yes, I consulted the book before I went to the University of Wisconsin.

Q. And it is your view that that book maintains that there is such a thing as inhibition, is it?

A. The book makes a statement that can be interpreted that way.

Q. And that is the statement that you quoted this morning on pages 244, 245 and 254?

A. Yes.

Q. Well, now I will ask you to turn to page 114 of that book, and the last sentence on the first full paragraph—not the full paragraph but the last sentence on the paragraph of page 114 reads:

> "A mixture of nodule bacteria from pea, clover, cowpea, and soy bean nodules are likewise not mutually antagonistic."

Do you agree with that or not?

A. I agree with that to which it pertains in this book. I have the original paper here by Alicante to which you are referring, and there is no data in this paper showing the exact details of these tests but Alicante concluded
288 that they could grow together just as well. He conducted no nitrogen fixation tests of any kind.

This antagonism does not refer to antagonism in respect to nitrogen fixation. I have the original book on the table if you would like to check the original article.

Q. Well, you are testifying, Mr. Bond, not me. I am asking the questions. You do not agree with that as being a statement—

Mr. Thiess: When you asked the question he wasn't presented the book. Would you like to see it?

Mr. Greer: I am not interested in it at all, I am merely asking whether he agrees with this statement that "a mixture of nodule bacteria from pea, clover, cowpea and soy bean nodules are likewise not mutually antagonistic."

A. With respect to growth.

Q. And I understand you to say that you do not agree with that.

A. I agree with it with respect to growth of the organisms, not with respect to nitrogen fixation. He conducted no tests on nitrogen fixation.

Q. Very well, if that is your interpretation of it.
289 Now, likewise on page 244 that you spoke of this morning, just above the heading "Composite Culture" there is a reference in there speaking particularly to the farmogerm culture. That was the farmogerm culture of the Earp-Thomas Company. That is referred to there, is it not, in that paragraph?

A. To the best of my knowledge, it is.

Q. And the sentence reads that according to Manns and Goheen, 16, Earp-Thomas, 21 and 22, and others, humus alone, where properly reinforced with nutrient salts, offers a very favorable medium for nodule bacteria. Did you consult that work of Manns and Goheen in your research to determine anything at all about the question of inhibition?

A. No. Manns and Goheen, the paper which I have checked contributes nothing in respect to nitrogen fixation by the plants.

Q. You are familiar with that publication that is referred to here, then, of Manns and Goheen, in 16.

A. Yes. Excuse me, I would like to get a summary of this paper.

Q. At any rate, as I understand it, your interpretation of that bulletin is that it teaches that there is no such thing as non-inhibition or inhibition.

290 A. This bulletin of Manns and Goheen—to my knowledge does not demonstrate either.

Q. It doesn't mention the question of inhibition or not?

A. No, in respect to nitrogen fixation, when we speak of inhibition, in regard to the patent we are not speaking of inhibition with respect to merely the growth of the bacteria.

Q. Do you think that if there is no affecting of the growth, that that would not be any indication of inhibition?

A. Of course, if the growth were affected the cultures would be antagonized or the growth would be reduced.

Q. And would the reverse be true, that if the growth was better with a mixture of the cultures that there would not be antagonism?

A. As far as growth is concerned; not as far as nitrogen fixation is concerned.

Q. Would it show anything with respect to nitrogen fixation?

A. It would not show a thing as far as nitrogen fixation is concerned.

Q. Very well. We will let it rest with that. Now, I want to turn to your patent again. At page 6, in
291 column 1, as I interpret this, you say, beginning with line 25, that your test consisted of—(reading):

"—a series of tests were made by planting red clover seeds in half gallon jars containing sterile sand supplemented with all essential minerals except nitrogen, and were inoculated as indicated below. After ten weeks of growth in the greenhouse under identical conditions, the sand was washed from the roots of the plants, the plants dried, weighed and ground and samples were analyzed by the Kjeldahl method for their nitrogen content.

"Each group or series of seeds was planted in a series of five jars and the standard deviation between the jars of each culture series was determined".

Then you say in the footnote down right after line 70 that the standard of deviation of the means of a series of five jars, and in the headings of your chart you say, first column: Grams dry weight per 10 plants, and in the third column: Milligrams nitrogen per 10 plants, and in the fourth column: Milligrams nitrogen fixed per 10 plants.

Does that mean that in each one of these five pots there were ten plants?

292 A. No; there were not ten plants in each of the five pots. To put it in terms of ten plants, it is a convenient measure to give me convenient figures for statistical analysis of the data.

It doesn't make any difference whether it is reported of ten plants, one plant, or one hundred plants. It does not change the significance of the results. But the amount of the dried weight for ten plants was obtained in this way: The number of plants grown was determined and the dry weights were determined, and the total dry weights of the five pots divided by the total number of plants in five pots, multiplied by ten, gives you the figure which gives you the grams dry weight per ten plants.

It is not an unusual procedure in outlining data of this nature to indicate it in that fashion.

Q. It is a positive statement that there were five pots in each series.

A. There were five pots in each series and I corrected that this morning by indicating that Series 2 and 4 were conducted with three replicates.

Q. Yes, but you have never made that correction with the patent Office, did you?

A. I didn't discover the difference until, in re-
293 checking my data in preparation for the trial. The significance of the means, when the standard deviation of the mean is taken, and this I know is just as significant whether you use three or five pots, as long as you adjust it with the standard deviation of the mean. I mean it is statistically acceptable.

Q. It doesn't make any difference whether you use three or five pots in the whole series; that is, three in each series or five in each series?

A. No; you can compare five in one series and three in the next series if you analyze it statistically.

The standard deviation of the mean increases as the number of pots decreases so that you have handicapped yourself in the smaller number of pots used.

Q. Then, as I understand it, what you actually did was a series which consisted of five pots?

A. Yes, sir.

Q. Series 2 of three pots?

A. Yes.

Q. Series 3 of 5 pots?

A. Yes.

Q. Series 4 of 5 pots?

A. No; four, Series 4 was three pots.

294 Q. Series 5 was 3 pots?

A. No; 4 was 3 pots and 5 was 5 pots.

Q. I didn't understand you.

A. Series 1 had five pots in it; Series 2 had three pots in it; Series 3 had five pots in it; Series 4 had three pots in it, and Series 5 had 5 pots.

Q. 4 had just three pots to it, did it?

A. 4 had three pots and 2 had thre pots.

Q. 2, 4 and 5 had three pots.

Mr. Thiess: No, 2 and 4.

The Witness: 2 and 4.

Q. (By Mr. Greer): 2 and 4, but 5 had 5 pots?

A. 5 had 5 pots.

Q. Now, I will ask you to tell me if there isn't another error in that chart, Mr. Bond, as I read the figures,—maybe my arithmetic is bad,—that 6.5 in the series which

is the amount of nitrogen that was in the seeds themselves in your control plant,—that is correct, is it not?

A. That is correct.

Q. Then the 122.0 in the next series, the 122.0 is the total nitrogen fixation including the 6.5 that was in the seed?

A. Yes.

295 Q. So to get the amount that was fixed by the bacteria that inoculates the plant, you subtract that 6.5 from the 122.0?

A. Yes.

Q. And that gives you 115.5 in the fourth column, is that correct?

A. That is correct.

Q. With that plus or minus of 10.0. Now, will you look down on Series 4 where you have the milligram nitrogen per ten plants of 80.8 and in the figures you submitted to the Patent Office as published in your patent is that the total nitrogen fixation from the bacteria is 72.3?

A. That is right.

Q. You do the same thing there to get that, don't you?

A. Yes.

Q. That is, you subtract 6.5 from 80.8?

A. Yes.

Q. Will you subtract that and tell me whether you get 72.3?

A. It should be 74.3.

Q. You never checked that or made any correction of that with the Patent Office?

A. I didn't notice that.

296 Mr. Thiess: I might state for the court's information that none of us have noticed that until just now but I would say it was an obvious error evident to anybody who would check the mathematics.

Mr. Greer: I say scientists are not supposed to make obvious errors or any other kinds of errors in submitting official tests to prove something.

Q. (By Mr. Greer) You produced as Plaintiff's Exhibits 14 and 15, photographs of tests which you have conducted showing the contrast of the uninoculated, the unmixed and the mixed strains of clover bacteria mixed with what other kind of bacteria was that,—Exhibit 14, for instance?

You mixed the clover in the third picture; you don't say what it was mixed with.

Q. (By Mr. Greer) Now 14 is a strain of clover;
297 that is the one on the right is a strain of clover mixed with what other kind of strain?

A. It is mixed with alfalfa strains and soybean strains.

Q. Alfalfa and soybean?

A. Alfalfa and soybean strains.

Q. And in Exhibit 15 you have a mixture of what?

A. Of soybean, alfalfa and clover.

Q. And the middle one is what, a single strain, unmixed?

A. That is 95-96.

Q. Clover?

A. No, it is soybean.

Q. It is single soybean in the middle?

A. Yes.

Q. And on the right it is a mixture of soybean and what?

A. And clover and alfalfa.

Q. Now, you produced those photographs of tests in which you claim inhibition is shown. As I understood your direct examination you ran a number of these tests and some of them showed what you called stimulation?

A. Yes.

Q. That means a beneficial nitrogen fixation in the mixed group, does it not, in the mixing of the strains?

A. Yes.

298 Q. Have you any photographs of those?

A. No, I haven't. I have the experimental data.

Q. How many tests, altogether, did you run?

A. Do you mean individual tests within a test or what do you mean by test,—the number of mixtures?

Q. Comparable to these exhibits. You produced photographs of two showing inhibition; I mean is it true that others showed stimulation, the opposite of inhibition?

A. Yes. These tests were conducted before the patent was applied for. At that time I did not know that I had stimulation. I had an indication in one experiment but the standard error overlapped, indicating it probably was not significant.

However, following this, in 1940 I ran a series, a large number of tests,—I believe there were about 400 pots in them,—and in those tests I found both stimulation and inhibition. Those are different tests than those in the photographs.

Q. But you only produced photographs showing inhibition?

A. Yes.

Q. You have no photographs showing stimulation?

A. I don't take photographs of all the tests.

Q. You don't take the ones unfavorable to your position?

A. I have photographs showing no inhibition.

299 Q. You have no photographs showing stimulation?

A. I have photographs showing no inhibition. They are in the patent proper.

Q. Showing no inhibition when they were in the mixed cultures?

A. When used in mixed culture.

Q. Photographs in the patent showing that?

A. It was discussed in the direct examination. Figure 3 representing a pot of clover plants in which the strains were single; Figure 4 representing a pot in which the strains were mixed.

Subsequent analysis of these plants showed no significance and difference between them indicating there was no inhibition in this case.

Q. Then it is a matter left to pure chance, as I understand it, whether there is inhibition or stimulation, or no effect whatsoever, as a result of this mixture, and the only way you can say whether it exists or not is to run standard routine tests?

A. It is necessary to run efficiency tests and to determine at least the dry weights and a more accurate estimation or determination is to determine the total nitrogen content.

Q. Now you knew when you went with the Kalo 300 Inoculant Company,—that was in 1937 I believe, was it not?

A. 1936.

Q. —that they were at that time putting out this garden-sized culture?

A. I don't recall if they were making it that year or not.

Q. How about 1937?

A. There was a period where the Kalo Inoculant Company did not produce a mixed garden culture. I don't remember back exactly what years they were, but I can check on it and give you that information.

Q. You know that they had sold a mixed garden culture before 1938?

A. Yes, mixed garden cultures, yes.

Q. The Kalo Inoculant Company itself had sold such a mixture, and that was composed of a plurality of different strains of the bacteria of the genus Rhizobium, was it not?

A. Yes.

Q. And there had been tests run on the strains, of the individual strains, that were in this mixture, to determine their efficiency in nitrogen fixation?

A. Yes. The cultures at one time were tested.

301 Q. The cultures at one time had been tested according to this standard efficiency test business that you have shown?

A. Yes.

Q. Now, they did not, as I understand you, run a test on the mixed culture itself?

A. Are you referring to since I have been there?

Q. Your knowledge of whether they had done it before you went there?

A. No. The Kalo Inoculant Company conducted no tests before I came there, of any kind.

Q. Or their predecessor, the Kalo Company?

A. Or the Kalo Company, not to my knowledge. I do not know that they conducted any tests. They were dependent upon Earp-Thomas for their information.

Q. It may have been even without showing the test that in this garden mixture there was what you now call an alpha strain of the bacteria?

A. There might have been. There was no way to know, without running tests.

Q. Did you ever see any plants grown by the use of this garden mixture?

A. Yes, the mixture will produce a benefit to the crop. Even a culture containing inhibitive strains will pro-

302 duce a benefit, will produce an increase over the uninoculated control, but will not produce the maximum, the optimum increase which could be obtained by a highly efficient culture.

Q. But you could tell from visual examination as to a beneficial result, if it was there?

A. If there was a distinct amount of it, as distinguished from the different controls, you could tell from visual observation.

Q. Now, you knew that these competitors of the Kalo

Inoculant Company likewise were selling similar garden mixed cultures?

A. Yes.

Q. And that was before 1937 or 1938?

A. Yes.

Mr. Greer: No further cross.

The Court: Any redirect examination?

Mr. Thiess: Just a few questions on redirect.

Redirect Examination by Mr. Thiess.

Q. Mr. Bond, you were questioned on cross-examination about a trip that you made to the Agricultural Laboratories, Inc.

303 How did you happen to make that trip? Were you solicited to come there by somebody in that company?

A. I was solicited to come there by the manager of the Agricultural Laboratories.

Q. And when did you make your trip?

A. To the best of my recollection it was in 1941.

Q. After your patent had been filed and issued?

A. Yes.

Q. And what was the purpose of going there? Why did they ask you to come?

A. To consult with them relative to a position in their laboratories.

Q. In other words, they wanted to employ you.

A. Yes.

Q. And that is the reason you went there?

A. Yes.

Q. And they paid your expenses?

A. Yes.

Q. Now, you have been questioned about these photographs, Exhibits 14 and 15, particularly, that you happened to have those; I would like to ask you if you can tell me what the Society of American Bacteriologists is and particularly the branch of that Society known as

304 the Agricultural and Industrial Bacterial Section?

A. The Society of American Bacteriologists is a scientific organization comprised of professional bacteriologists in all the different fields of bacteriology.

This Section, which you refer to, deals with bacteriology in its application to those particular fields.

Q. And is that a well-recognized society in this particular art?

A. Yes, it is.

Q. (By Mr. Thiess) And, as I understand it, on Au-

gust 30, 1938 you read a paper before the Society, did you, on this matter of your discovery and what is contained in your patent?

A. Yes.

Q. And were these two photographs, Exhibits 14 and 15, prepared to make slides for this paper?

A. Yes.

305 Q. (By Mr. Thiess) You were referred to a quotation from the book: Root Nodule Bacteria in Leguminous Plants, and I would like to have you read into the record the sentence prior to the part that was quoted.

A. Alicante, 1926—

Mr. Greer: Where are you reading from?

Mr. Thiess: The sentence just prior to the one that you quoted to him.

Mr. Greer: On what page.

The Witness: Page 114.

A. (continued) Alicante, 1926, found a number of organisms non-injurious to the Rhizobia, i.e., B. radiobacter Azotobacter chroococcum, B. prodigiosus, B. capsulatus, B. subtilis, B. mesentericus, a pink yeast and
306 some molds. A mixture of nodule bacteria from pea, clover, cowpea and soybean nodules are likewise not mutually antagonistic."

Q. Now, as I understand it, that is not the statement of the author's but a quotation from the paper by Alicante, is that correct?

A. It is not a quotation from the paper of Alicante; it is a summary made by the authors of the paper, a part of the paper.

The Court: Will you have the witness tell me where he claims that what he has done in disclosing the patent here, where it differs in principle from the garden product that was referred to in the cross-examination, where there was a variety of cultures used for the garden seeds?

Q. (By Mr. Thiess) Will you answer that question?

A. Garden cultures are a mixture of different groups and the components, the different component species, have been presumably tested for efficiency.

What effect they have on each other in the mixture was not known, and as far as our own product is concerned, we do not know now, but there was nothing to indicate whether the organisms were noninhibitive or not.

307 It is a simple mixture. The patent refers to a

mixture of prepared and selected strains so that you know it is a good culture. The garden cultures were thrown together and there was no way of telling whether it was going to produce a maximum or optimum increase in yield.

The Court: You only judged by the fact that there was some beneficial results?

The Witness: There was some beneficial results and that was satisfactory for the purpose this culture was intended.

The Court: So far as your combination is concerned, you have the same thing except that you have selected them scientifically, we will say.

The Witness: So that a maximum result, an optimum result is obtained. There is a very important difference. There are two problems involved, as far as the garden culture and the field legume seed cultures are concerned.

The garden culture is used on a small amount of seed in gardens where normally the seeds are planted in a fairly rich soil anyway; any increase in yield will be beneficial to those garden plants.

But in the field you have a different problem. The unique advantage of selecting a highly efficient culture
308 of optimum strains, so that the best possible increase can be obtained, is a very important one.

A strain that is 20% less in a field culture would produce a serious economic loss, whereas a strain that might be 20% less in a garden culture would produce less garden yield but doesn't have the same significance that the other does.

The Court: Was there any commercial product put out for use for clover and alfalfa and soybeans of a combination prior to your patent?

The Witness: There were some cultures on the market. There were none on the market at the time the patent was applied for. The tests on the other products—

The Court: When you say there were none on the market at the time the patent was applied for,—were there any when it was issued?

The Witness: Our own product was on the market when it was issued. There were none others, so far as I know.

The Court: Your own product built according to the patent?

The Witness: Built according to the patent. Previous to the patent mixed cultures had been prepared. Some

were claimed to be good on all legumes and some
309 were claimed to be good on just a few.

The results obtained with these cultures were very uncertain. Sometimes they didn't even form nodules on the plants for which they were recommended. In other words, the need for a mixed culture was shown in the early history of these mixed cultures but none of them survived on the market, to my knowledge anyway, much after 1930 when there were more intensive culture tests made by the State and the United States Government institutions.

Mr. Thiess: I just would like to ask one other question that might clarify that.

The Court: Yes.

Q. (By Mr. Thiess) In a garden culture would you get a result that would give you ultimate results on each of the seeds contained in the garden cultures equal to that if these seeds were inoculated by the single culture specific to each of the seeds in the garden culture?

A. No one knew. I mean, to the best of my knowledge no one had ever tested the individual strains in the garden cultures and compared them with the final mixture.

Mr. Thiess: Does that help?

The Court: Yes; I appreciate that; it was too small a business to warrant it.

310 The Witness: Yes; we have devoted what time we have for research to developing our field culture. We are doing a little work at the present time on the garden cultures and as soon as we can, that culture is going to be thoroughly checked to make sure that every strain which is there will produce optimum results.

We know that when they went in they were efficient strains but after they have been in the mixture we are not sure exactly how efficient they are.

The Court: I think that is clear.

Mr. Thiess: And your Honor understands the economics, does he, between this inoculation of seeds for field culture as compared with garden cultures?

The Court: Oh, yes.

Mr. Thiess: That is all.

Mr. Greer: Nothing further.

(Witness excused.)

The Court: Call your next witness.

Mr. Rathburn: Mr. Lusk.

MYRON E. LUSK called as a witness on behalf of the plaintiff, being first duly sworn, was examined and testified as follows:

Direct Examination by Mr. Rathburn.

311 Q. Will you please state your full name and your residence?

A. Myron E. Lusk; 2116 Aldo Boulevard, Quincy, Illinois.

Q. What is your present occupation?

A. President and general manager of the Kalo Inoculant Company.

Q. How long have you been in the inoculant business?

A. Oh, about 13 years.

Q. By what company were you first employed?

A. The Kalo Company.

Q. In what capacity?

A. In charge of sales.

Q. Would you explain just generally how the Kalo Company carried on its business at the time you were first employed by them with respect to inoculants?

A. The Kalo Company, when I first started to sell inoculants for them, were sales agents for Humogerm, manufactured by Earp-Thomas Laboratories.

Q. Do I understand that the Earp-Thomas Company manufactured the culture?

A. They manufactured the culture under their own name and the Kalo Company acted as sales agents selling it and billing it and shipping it.

312 Q. The Kalo Company did what?

A. The Kalo Company sold it, and shipped it, and billed it, and paid Earp-Thomas Laboratories so much per unit for it.

Q. What was your experience with this culture so far as its success was concerned?

A. Most unfortunate.

Q. Would you elaborate on that a little bit?

A. Well, to begin with, Earp-Thomas Laboratories couldn't make enough deliveries to take care of the business which the Kalo Company secured. They lacked sufficient finance to buy cans and humus, etc., and the Kalo Company had to advance them money and ship them carloads of humus from Illinois. Then the quality was very bad.

The Kalo Company had no bacteriologists. They had nobody who knew anything about it. They were dependent upon Earp-Thomas, so when some poor tests started to come through, the Earp-Thomas Laboratories was approached about it and had an excuse that it was caused by this or that,—it would be corrected, and we wouldn't have any more trouble, but the next year would be worse.

Q. What was finally done about this?

A. Finally, in 1935, the state of Wisconsin notified
313 the Kalo Company that their license for the sale of the culture in that state would not be renewed the next year and I met Earp-Thomas in Chicago and went to Madison, to find out what could be done about it.

Finally, the arrangement was made that Earp-Thomas would not supervise any more cultures for the Kalo Company. If the contract were to be continued that a bacteriologist employed by the Kalo Company would be put in charge of production.

Q. And did you employ such a bacteriologist?

A. We employed two—

Q. What were their names?

A. —at the recommendation of the University of Wisconsin.

Q. What were their names?

A. One of them was there for just a short time to make an initial inspection and get things ironed out. That was Mr. Mickelson and another one was Leo Dick.

Q. And do I understand that Mr. Mickelson was at the Earp-Thomas Laboratories in your behalf for just a short time?

A. Yes; my memory is about two months.

Q. And from then on, do I understand that Mr. Dick was there?

314 A. Mr. Dick continued there as long as there was any contact with Earp-Thomas Laboratories, which was about, I should say, 15 or 16 months, until Mr. Bond was employed and we built the laboratory here for Kalo Inoculant Company.

Q. Are you still in the employ of the Kalo Company?

A. No; not since 1939.

Q. When was the Kalo Inoculant Company formed, and for what purpose?

A. In 1934, to finance the Kalo Company's operations on inoculation.

Q. And what was the working arrangement that they had with the Kalo Company at that time?

A. The Kalo Company sold and produced the inoculation and the Kalo Inoculant Company financed it and the Kalo Company got a percentage.

They were put in that financial difficulty by the inferior culture which Earp-Thomas had delivered.

Q. You referred a moment ago to hiring Mr. Bond. When did that occur?

A. He started with us, I think, in September, 1936.

Q. And what was your purpose in hiring Mr. Bond?

A. We had to figure whether to get into the inocu-
315 lation business or get out of it. We decided to go into it and build a laboratory and put a qualified man in charge.

Q. And what was the first thing you asked Mr. Bond to do after he was hired?

A. Well, when Mr. Bond was employed, the arrangement was that he was not to be interfered with in any way in the production of a good culture.

He was to be permitted to build his own laboratory, equip it as he thought best and to continue the research work he had been doing at the University of Wisconsin.

There wasn't any direction given to Mr. Bond as far as that culture was concerned. Along towards spring,—I would say May or June, I did ask him to undertake to find out why these mixed cultures were not successful and to see if one could not be made.

Q. Why did you want to make a mixed culture?

A. Primarily because the profit in the business lay in it. The operation was pretty small at that time. Returns were pretty heavy and the amount of returns até up the profit.

The unsold culture that would come back in the industry would frequently run to 30% and at the time of the Government hearings several years ago to con-
316 serve material they made some arrangements on the handling of those returns, and it was stated that the industry average was 20% returns.

Q. You felt you could cut down these returns?

A. There was no question about it because the returns originated from dealers' and jobbers' attempts to supply the farmers, which wasn't working out too good.

These cans come out a dozen to a case and in the spring a dealer normally will get what he thinks is a conservative part of his requirements. He cannot buy it all because he doesn't know how much seed of a certain kind will be

planted, but he does buy some stock. Clover is started to be planted, and it is pretty hectic about these seed dealers in clover seeding time.

They are pretty busy passing out clover seed and inoculation. The first thing they know they don't have much clover inoculation left. Then they are going to have to decide whether they are going to want any more in. If they do they will be stuck, if it isn't sold. It will be on their hands if they don't sell it, and although they get 50% of their cost back, they do have that loss and have the trouble sending it in and so they don't buy.

We wanted to make culture more available to farm-
317 ers, particularly in the small towns where it would help the small seed dealers, and where it might be, at the end of the season, where there would be no single culture available, for them to have the mixed culture.

He can sell it early in the spring for clover, later on for alfalfa, then in the course of the summer for soybeans, and again in the fall he can sell it again for alfalfa.

Q. Do you recall what Mr. Bond's reaction was to your request?

A. He rather laughed at me. He thought it would be impossible and didn't hesitate to say so, but I asked him not to make up his mind so fast but to investigate and see if there wasn't some error that could be found in some of this work, or some way he could find to make it, and he was going to the University of Wisconsin that summer to do some work on his Doctor's degree and said he would have an opportunity to re-investigate and read the literature and possibly could develop some idea about it.

When he returned in the fall he still wasn't optimistic. He was very far from it, and as I remember it, he told me then that there really wasn't much use fooling with it but
he did have an idea that it just might work, that he
318 might have located where the trouble was, and the way to correct it, and that he would like to set up some experiments in the spring. It was too late then to set them up in the fall; it would get too cold before he could do it, but he would have to have certain equipment, and would it be all right for him to buy it? And that was approved and these experiments were started.

319 Q. When was this Uni-Culture, which I understand is the product manufactured under the Bond patent first announced to the trade?

A. The first announcement was at the American Seed Trade meetings held at Detroit or Cleveland the latter part of June 1938. Deliveries, however, were not made until after the first of January 1939.

Q. To the best of your knowledge, was there any mixed culture for field seeds being offered for sale at the time that Uni-Culture was announced to the trade?

A. No.

Q. How was Uni-Culture received by the trade?

A. Very well. The business jumped on clover and alfalfa fifty-seven per cent the first year as a direct result of Uni-Culture. However, the biggest complication was the reaction of competitors.

Q. What was that reaction?

A. Very soon after Uni-Culture was announced we began to get the word the bacteria would fight, it wouldn't work, and we were foolish to put it out and no one should handle it. It culminated when the largest manufacturer got out a bulletin against Uni-Culture signed by his bac-
320 teriologist and we really felt that because they were prominent in the trade.

Q. Did you ever see one of these announcements by this competitor's bacteriologist?

A. Yes.

Q. I hand you a document and ask you if you can identify that. (Handing document to witness.)

A. That is the document to which I was referring. I can also identify the other.

Q. Did you ever see the original letter from which this was copied?

A. I did.

Q. How did it come into your possession?

A. By mail from one of our jobbers.

Q. Do you remember the name of that jobber?

A. I do.

Q. Do you know where the original letter is now?

A. The original letter was returned to them for their files.

Q. Do you know whether Mr. Sexauer, to whom this original letter was addressed, is still alive?

A. Mr. Sexauer is. Mr. Clark is not. He was the manager of the Sexauer Company.

Mr. Rathburn: If the Court please, I would like to read

into the record this letter which the witness has just
321 identified.

Mr. Greer: I would like to see the letter first.

(Document handed to Mr. Greer.)

The Court: For what length of time does it maintain its efficiency after it is put in cans?

The Witness: We date it for nine months. One year on single culture. We have experiments covering the period of twenty-six and twenty-eight months but, under the conditions of storage, we don't believe it should be dated that far ahead.

322 Mr. Rathburn: The letter reads as follows:

"George P. Sexauer & Son,
Des Moines, Iowa."

It is dated July 21, 1938.

"We have your advance NITRAGIN contract memorandum dated July 18, 1938, sent in by our Mr. C. A. Thomas. We are sending you at this time 200 red circulars like copy enclosed.

See copy of a report on the new big discovery Uni-Culture given me by our Dr. L. W. Erdman. Investigation has disclosed that they are simply mixing these cultures. It is not new at all. Records show that this was tried out many years ago and never has proven successful. We have been sending out a combination culture in the Garden Size for years for peas, culture
323 'C', beans, culture 'D', and lima beans, culture 'E' and for Lupines. We can do this successfully because the amount of seed is exceptionally small. These different groups of legume bacteria when mixed do not multiply at the same rate while in the container and this means that in due time one group has dominated the other. This means that these cultures cannot be depended upon after being in containers for some time. We thank you very kindly for the splendid cooperation you are giving us and we hope sincerely you will have a very successful year.

Very truly yours,

The Nitragin Company, Inc.

(Signed) L. D. Matchette"

Doctor Erdman's report reads as follows:

"Milwaukee, Wisconsin.
June 10, 1938.

To: Mr. L. D. Matchette
324 Re: Uni-Culture prepared by Kalo Inoculant Company.

Dear Mr. Matchette:

Careful study has been made of the claims, advertising and merchandising appeal of the announcement of Uni-Culture, which undoubtedly will provoke some thought among distributors of inoculants.

1. The name Uni-Culture is grossly misleading. It implies one culture for all legumes, whereas the announcement states only three cross-inoculation groups are involved, 'One can inoculates clovers, alfalfa, soy beans'.

2. The idea is far from being new, and if a patent should be granted it would mean nothing. Quoting from University of Wisconsin Studies in Science No. 5, pages 244-5, by Fred, Baldwin, and McCoy."

325 "*Composite culture.* The desire to have one culture for several crops has led to the preparation of the so-called 'dual purpose' or 'universal culture,' Bredemann, 1912, and Vogel, 1917. In some such preparations, rhizobia of only two or three cross-inoculation groups are included, while in others the makers have gone to the extreme of mixing representatives of all of the more common cross-inoculation groups. Although this method may bring about fair nodule formation, the results are variable. The writers feel that composite cultures offer few advantages and certainly many disadvantages. Perhaps the only justification for this mixing of strains is in the case of the small-size garden culture. Because of the limited amount of seed to be sown, it may be desirable to have one culture containing the organisms for such crops as beans and peas and thus to reduce the cost of inoculation."

326 "3. The distributor letter states 'uni-Culture is the result of years of research and is announced only after having thoroughly proven its efficiency in severe laboratory, greenhouse and field tests. Uni-Culture results are equal in every respect to those secured by

the best single cultures, even after months of storage.' Such statements without authoritative proof mean absolutely nothing.

4. 'Uni-Culture—Greatly reduces returns—Reduces stocks of culture and sizes carried 2/3'. This is purely a sales appeal. It will interest a few dealers, like the 'dry-applied' culture, but results to be had by the farmer should be the ultimate consideration.

The Nitragin Company's policy has been to prepare a culture that will produce excellent results on legumes grown under a wide range of soil and climatic conditions. To accomplish this it is necessary to give prime consideration to such factors as large numbers, selection of highly efficient strains, etc.

We could grow a pure culture liquid suspension of a
327 selected number of strains of alfalfa group bacteria in one tank. In another tank we could grow the red clover group of bacteria, and in a third tank our selected strains of soybean bacteria. We could mix these suspension separately with the humus and then mix equal portions of the alfalfa, clover and soybean NITRAGIN. This would be the equivalent of UNI-CULTURE.

All other conditions being equal, and in order to give the same number of legume bacteria as we pack in our one bushel size, we would have to use a can three times as large as the one bushel size. If we would use the regular size one bushel can, we would be cutting the quantity of NITRAGIN to one-third for each culture group. Fine for the manufacturer but not so good for the farmer.

Another factor, which might seriously interfere with the efficiency of such a culture is the rate of growth of the different legume bacteria. We believe that most manufacturers of humus legume inoculants depend upon the increased growth of the legume bacteria after
328 they are mixed with the humus. It would be almost suicidal to mix a slow growing organism like the soybean bacteria with fast growers like the alfalfa and red clover bacteria. Such a culture if prepared, say in January, would theoretically contain relatively few soybean bacteria when it would be used on soybeans in May or June.

Many other points might be mentioned to elaborate on the disadvantages of such a culture as Uni-Culture. This should suffice until we are able to obtain authoritative opinions from outside sources.

Very truly yours,
The Nitragin Company, Inc.
Lewis W. Erdman, Director
Research and Production."

Mr. Rathburn: Q. Did you ever make any reply to that letter by Mr. Matchette to Mr. Sexauer, Mr. Lusk?

A. After we heard about that letter from several different persons, I wrote to Mr. Matchette to call his attention to the inaccuracies in the letters he had distributed and asked him for a correction. When no correction was forthcoming, I photostated the letter to Mr. Sexauer, photostated a copy of my letter to Mr. Matchette, and cir-
329 culated that to the seed trade.

Q. I hand you a document and ask you if you can identify this (handing document to witness)?

A. That is the letter written to Mr. Matchette to which I received no reply and which was circulated to the seed trade.

Mr. Rathburn: I offer in evidence as Plaintiff's Exhibit 17 the letter identified by the witness.

The Court: It may be received.

(Said document, being a letter from Mr. Lusk to Mr. Matchette, so offered, was received in evidence by the Court and marked Plaintiff's Exhibit 17.)

Mr. Rathburn: Q. Do I understand, Mr. Lusk, that when you first put UNI-CULTURE on the market it was a three-in-one culture for alfalfa, clover and soybeans?

A. That is right.

Q. Have you since put out any other form of Uni-Culture for field seeds?

A. Yes, we make it also for clover and alfalfa only.

Q. Why do you put out the two types of Uni-Culture?

330 A. After we put out the culture for three, including soybeans, the price of soybean cultures from some competitors was considerably lowered by which it could be purchased by the farmer cheaper than the soybeans could be purchased in a Uni-Culture combination.

We had a choice to make as to whether to reduce the price of Uni-Culture to the soybean basis or to bring out a single culture for soybeans at a competitive price. We didn't feel it was a good thing from the jobbers' and dealers' standpoint to put the full Uni-Culture combination on the soybean basis because the profit per can would be so low that they might not be interested in carrying it and handling it and selling it to the farmers.

Q. So then you brought out the so-called two-in-one culture which was applicable only to clover and alfalfa?

A. We make both Uni-Culture 3 which is clover, alfalfa and soybeans and Uni-Culture 2 which is for clover and alfalfa only.

The sales divide largely geographically. The three-in-one culture sells mostly to the north where the soybeans are not such an important crop. Through this area they buy Uni-Culture 2 plus the single culture for soy-
331 beans.

Q. Now, I believe you stated that at the time Uni-Culture was introduced on the market no national distributor or nobody had on the market a mixed culture for field seeds?

A. I know of none.

Q. How many national distributors of inoculants are there today?

A. Six that are recognized.

Q. How many of them now sell a mixed culture?

A. Three that I know of.

Q. I understand one of them is the Kalo Company and another is the Agricultural Laboratories.

A. Kalo Inoculant Company.

Q. Kalo Inoculant Company?

A. And the third is the Albert Dickinson Company.

Q. Could you give me the name of their product?

A. Simplex.

Q. Do you know approximately when Agricultural Laboratories put their combination Legume-Aid on the market?

A. 1941.

Q. Were you familiar with the fact that Agricultural Laboratories attempted at one time to hire Mr. Bond?

A. Yes.

332 Q. How did you happen to become familiar with that?

A. He told me that they were talking to him and that they had sent him money for expenses to come and see them and he wanted me to know about it and I advised him to go, to go and talk to them. If they had something better to offer than we had to offer, I wanted him to have it.

Q. Was that before or after the Agricultural Laboratories put their Legume-Aid on the market?

A. Before.

Q. I believe you testified a moment ago, Mr. Lusk, that your sales increased 57 per cent the first year after you put Uni-Culture on the market?

A. Correct. That is the sales of clover and alfalfa culture.

Q. Do you have any figures that would indicate how much they have increased since that time?

A. They have increased two and one-half times since the Uni-Culture was brought out.

Q. Do you have any figures on the approximate amount of clover and alfalfa Uni-Culture you sold last year?

A. Oh, I would say enough for about three-quarters of a million acres.

333 Q. That is enough Uni-Culture to plant approximately three-quarters of a million acres of alfalfa and clover combined?

A. Either.

Q. Does the Kalo Inoculant Company still sell single cultures for alfalfa?

A. No.

Q. Or single cultures for clover?

A. The first year after Uni-Culture came out we did have single cultures, but only 11 per cent of our total sales were on single cultures and the next year they were none. We didn't carry them beyond that.

Q. Will you please explain just generally what you consider to be the benefit to the farmer of a mixed culture?

A. The biggest benefit I can see for the farmer lies in its availability, particularly at the end of the planting season. You will recall a little while ago I spoke of the fact that the dealer had to decide whether to order inoculation after he ran out at the close of a planting period or risk getting stuck.

The result has been that as the season came to a close

and the business instead of being a rush was a trickle,
334 culture has not been available to the farmer, particularly in the smaller towns or the small seed dealer but with composite culture the dealer can handle it without the risk of getting stuck and it is easy for him to maintain a stock. He just buys so many cases.

You see, when Uni-Culture came out the ordinary dealer had to carry nine different sizes to accomplish what Uni-Culture accomplished in three. That is we had one-half bushel clover, one bushel clover and two and one-half bushels.

Q. What has been the policy of the Kalo Inoculant Company so far as marking the patent number of the Bond Patent on this Uni-Culture?

A. When the first Uni-Culture label was printed the patent had been applied for and "Patent Applied For" was put on it. Immediately after the patent was allowed the Patent Number was put on the label and has been there continuously since that time.

Mr. Rathburn: No further direct examination.

335 *Cross-Examination by Mr. Greer.*

Q. Mr. Lusk, with regard to the dealer handling your Uni-Culture which is a mixed culture, we will say, for alfalfa and clover, if you take this one package, he has got to put into one package the same number of bacteria that he would have to put in the single culture to cover the same territory when it is used by the farmer, would he not?

A. Yes.

Q. Therefore, one package of the single culture would be just half the size of this package which is for the combination, would it not?

A. Not necessarily. I am not a bacteriologist and don't propose to endeavor to answer those kind of questions because I can't answer, but, as I understand it, the size of a package has been the manufacturer's idea as to what amount he wanted to supply for easy mechanical distribution over the seed and had little relation with the capacity to hold bacteria, if that is what you mean.

Q. I mean you have got just enough bacteria in here,

according to your label, for one bushel of alfalfa or 336 clover?

A. Or two bushels of soybeans.

Q. Or two bushels of soybeans?

A. That is right.

Q. Now, say, that you have a single size, take your former single culture for one bushel of alfalfa, it would be approximately one-half the size of this one?

A. The same size exactly, because in our experience it required that much humus in order for the farmer to readily distribute it over his seed.

Q. At any rate, the Kalo Company originally had a contract with the Earp-Thomas Company for obtaining these cultures?

A. Yes.

Q. I hand you a photostatic copy—the original is somewhere around here—of a document entitled "Culture Chart" and a 1932 price list purporting to have come from the Kalo Company. Are you familiar with that chart as having been gotten out by your company, or one like it? I don't mean that identical one. (Handing document to witness.)

A. It has been so long ago, and so many pieces have gone out, but it looks like it might be.

Q. And that advertises a garden size culture on it, 337 does it not?

A. Garden.

Q. For peas, beans, sweet peas, lima beans, for twelve bushels of seed?

A. Yes.

Q. Now, that was a mixed culture, was it not?

A. Yes, sir.

Q. And that was sold under this trade name of moist powder Humogerm a humus based legume inoculant made with Farmogerm bacteria?

A. I presume so.

Q. How long did you continue selling—this is dated 1932—how long did you continue to sell that kind of product?

A. I think that the garden size was discontinued in 1934.

Q. When?

A. 1934.

Q. 1934?
A. Yes, 1934.
Q. And how long had you been selling it before 1934?
A. That price list would indicate two years, because they started selling it in 1932.
338 Q. Had you sold it before 1932 at all?
A. No.

Mr. Greer: I would like to have this circular marked—Culture Chart and 1932 price list marked for identification as Defendant's Exhibit 1.

(Said document being culture chart and 1932 price list was marked Defendant's Exhibit 1 for identification.)

Mr. Greer: Q. Did you ever see a label of this kind of the Earp-Thomas Laboratories, of Bloomfield, New Jersey?
A. No, I didn't. I understood they had stolen it.
Q. When did you understand they were selling a humogerm under a label like this?
A. After the Kalo Inoculant Company canceled their contract with them.
Q. That was in 1934?
A. No, sir, that was 1938.
Q. When?
A. 1938.
Q. 1938. Well, what did the Kalo Company sell between 1934, and 1938?
A. Well, the Kalo Company sold Earp-Thomas Cultures or cultures from the Earp-Thomas Laboratories
339 during that period, but it wasn't made by Earp-Thomas after 1935; it was made by Leo Dick at Earp-Thomas Laboratories.
Q. Well, was it still sold as Humogerm?
A. It was sold under Humogerm until July 1938.
Q. And it still was this garden size culture?
A. No, there was no garden size culture.
Q. Didn't have a garden size culture after 1934?
A. Not that I know of.
Q. Have you employed a garden size culture since then at all?
A. The Kalo Inoculant Company produced a garden size culture last year.

Q. Last year?

A. And is making it again now.

Q. Was that the same kind of garden size culture the Kalo Company had originally sold?

A. No, this was a good culture.

Q. What?

A. This was a good culture. I was under the opinion we did not get a good culture before.

340 Q. Now, as I understand you, in 1937 you suggested to Mr. Bond that you were desirous of having a composite culture containing two or more different strains of this bacteria?

A. I don't know whether we discussed two or more or all of them; I don't know.

Q. Well, a plurality of them, at any rate.

A. Yes.

Q. And that was your idea?

A. Yes, sir.

Q. And Mr. Bond told you then that he did not think it could be done very definitely, and he then went to the University of Wisconsin and came back and confirmed his statement that you could not have a composite culture?

A. But he had found an idea upon which he might base some hopeful experiments.

Q. And you told him to go ahead, that you wanted him to try to do it?

A. That is right.

Q. That your idea was to bring out this composite culture?

A. Providing one could be produced that was good.

341 Q. Yes, and that was the birth of this Uni-Culture?

A. Yes, sir.

Mr. Greer: I don't think there is any further cross examination.

Mr. Thiess: Well, then, plaintiff rests.

Whereupon plaintiff rested its case in chief.

343 Whereupon, at 4:05 o'clock P.M. Tuesday, June 26, 1945, an adjournment was taken until 9:00 o'clock A.M. Wednesday, June 27, 1945.

344 IN THE DISTRICT COURT OF THE UNITED STATES

Southern District of Illinois

Wednesday, June 27, 1945.

9:00 o'clock A.M.

Trial resumed pursuant to adjournment.

345 And thereupon the defendant, to maintain the issues on its part, introduced the following evidence, to wit:

IRVIN HAROLD CURIE, called as a witness on behalf of the defendant herein, being first duly sworn, testified as follows:

Direct Examination by Mr. Staley.

Q. Mr. Curie, would you please state your full name, your age and your present occupation?

A. Irvin Harold Curie. Age 44 years. I am Director of Research of Agricultural Laboratories.

Mr. Staley: Q. You are the same Mr. Curie that has previously testified in this present case with reference
346 to the products of the Agricultural Laboratories, Incorporated, of Columbus, Ohio, are you not?

A. I am.

Q. Mr. Curie, would you please give us your education and experience with reference to the field of plant pathology or bacteriology?

A. I received my Bachelor of Science Degree in 1923 from the College of Wooster, Wooster, Ohio.

I received my Master of Science Degree from Ohio State University in 1930.

In 1933-1934 I spent a year in residence at Ohio State University working in work towards a Doctor's Degree.

In regard to experience, beginning in 1923 I was employed at the Ohio Agricultural Experiment Station at Wooster, Ohio as a member of the Scientific staff and in the Division of Soil Biology as Assistant Soil Biologist.

In 1926 at the Station I began working on the legumes and legume bacteria and handling cultures for the same.

In 1927 and 1928 we began testing commercial cultures at the experiment station. These included greenhouse 347 tests. This work continued on into 1933.

In June 1933 I resigned from the Experiment Station Staff to take up a fellowship established by the McQueen Bacteria Company of Baltic, Ohio. They were manufacturers of inoculants. This fellowship was established to develop methods of producing a better inoculant, humus inoculant, and included the work previously mentioned at the Ohio State University in '33-'34.

In June 1934, on completing this fellowship, I was employed by the McQueen Bacteria Company as Bacteriologist and to supervise the production of their cultures. I was employed there until October 1937, at which time I went to Agricultural Laboratories, and have been continuously in their employ since that time.

Q. Now, Mr. Curie, in your experience in the field of legume bacteria and inoculants, have you made any nitrogen determinations of various legume plants?

A. I have made many such determinations.

Q. Have you made any other type of tests with reference to legume plants to determine the efficiency of one strain of legume bacteria relative to others?

A. Yes, I have.

348 Q. What type of test is that to which you refer?

A. Well, I have made greenhouse tests regarding the plant growth and followed by cropping the plants, determining their weights and their nitrogen content.

Q. So that you have had experience in the generally accepted methods of testing the legume bacteria to determine their efficiency from the symbiotic relationship of these bacteria with the legume plants?

A. I have.

Q. Now, Mr. Curie, with reference to your earlier testimony and the products of the Agricultural Laboratories, Incorporated, of Columbus, Ohio, you referred to the Legume-Aid inoculant that has been identified as Plaintiff's Exhibit No. 1. Did you have the manufacture of this inoculant under your control?

A. I did.

Q. Are the strains of the clover bacteria and of the alfalfa bacteria that are used in that Legume-Aid inoculant strains that are a part of your general stock culture of bacterial strains?

A. They are.

Q. Do any of these strains extend back in age prior to the date of the Bond Patent—

349 A. Many of them do.

Q. (Continuing:)—of August 24, 1938?

A. Yes, they do.

Q. During your period at Agricultural Laboratories have you ever made any nitrogen determination tests with reference to the efficiency of the use of a single strain of bacteria, with reference to the use of that same strain in combination with other bacterial strains or cross inoculation groups?

A. I have.

Q. What was the general type of that test you made, of the comparison?

A. That was a test conducted during the past year.

Q. Are those specific nitrogen determination tests to show the efficiency of the bacteria upon the legume plants?

A. In this particular test run this past year they were.

Q. Before this past year, that you refer to, did you ever previously make any nitrogen determination tests?

A. I have not made any nitrogen tests previously since I am in commercial inoculation work.

350 Mr. Staley: Q. And you have not specifically compared one strain of bacteria, such as the clover strain of bacteria, with another strain of bacteria in association with that strain prior to this present year?

A. No, I have not.

Q. That can be said of the cultures that went into the production of Legume-Aid which has been referred to as Plaintiff's Exhibit 1?

A. It is.

Q. You stated that you had been employed by the McQueen Bacteria Company of Baltic, Ohio in 1934. When you were at McQueen Bacteria Company were you in control of the manufacture of the inoculants?

A. I was.

Q. Would you give us the method of preparing the single strains of the bacteria while you were at the McQueen Bacteria Company?

A. Do you want that going clear back to the original culture? The methods are the methods commonly used.

We grew them—

351 Q. I would like for you to state the method in somewhat general terms without going into the specific details of isolation and carrying forward, but speaking of it in the general terms of the methods well known in the art.

A. Well, beginning with the test tube pure strain cultures we inoculated from this into pint bottles on nutrient agar and allowed growth to take place in that nutrient agar or on that nutrient agar for a period of five days or more as required.

After this growth had taken place we poured water into the bottle, filling it about half full, and then scrubbed the growth from the surface of the agar, mixing the growth into the water in a bottle and then pouring it out into suitable containers.

Q. Just what do you mean by scrubbing the growth from the agar?

A. The growth is on the surface of the agar. To merely put in water and pour it out again would remove some bacteria but, in order to remove all, or substantially all of them, they must be scraped or scrubbed from the surface.

Q. Did you remove any of the agar from the bottle?

352 A. There may at times have been particles broken off. We did not want to remove the agar.

Q. Please proceed.

A. This suspension prepared from a number of bottles, according to the quantity of humus to be inoculated, was then mixed thoroughly into a peat humus base.

Q. Just what do you mean by "suspension"?

A. "Suspension" is commonly—as we speak in this meaning is a mixture of bacterial cells in water or in a liquid medium. In this case suspension of the cells in water.

Q. In this case just exactly what did this suspension consist of?

A. It consisted of bacterial cells, a small amount of nutrient material, which was the surface of the agar, and would be carried into the agar, and water.

Q. Will you proceed, please, with the preparation of the product then?

A. After this product was mixed in the manner men-

tioned, it was packaged into suitable containers and placed on the market for sale.

Q. You mentioned that you used a peat. Is that comparable with the term that has been previously used,
353 "humus"?

A. Yes, peat humus, sometimes referred to as peat and sometimes as peat and at others as humus.

Q. Did this base material known as peat or humus have any bacterial nutrient in it that would support bacterial life?

A. It does have nutrient in it that will support bacterial life.

Q. Did you ever make any tests with reference to the strains of bacteria that you used at McQueen Laboratories at Baltic, Ohio?

A. Yes, they were regularly tested in the greenhouse for nodule formation and nitrogen fixation.

Q. If I understand you correctly then, you ran greenhouse tests?

A. Yes.

Q. Did you run nitrogen determination tests?

A. I did not.

Q. Did McQueen's, to your knowledge, ever produce a mixed culture that could be said to be a combination of more than one of the cross inoculation groups of legume bacteria?

A. They did. They were manufacturing such a
354 product when I went there and continued manufacturing during the entire period I was there.

Q. Do you know what that product was?

A. That was the garden inoculant which contained bacteria for plants of the pea, the bean, the lima bean and the lupine group.

Q. Now, you refer to those as "group", cross-inoculation groups of the legume bacteria? Would you indicate how many groups are in that garden mixture?

A. There were four groups in the garden mixture.

Q. I now hand you herewith a package that is entitled, "INOCULATION", "McQueen's Inoculator". "Good for Sweet Peas—Lupines, Garden Peas and Beans", and ask you if you identify that package?

A. Yes, I have seen many packages similar to that.

Q. Is that the type of product you were referring to as the garden mixture?

A. It is.

Q. Can you tell us the approximate time when the products of that nature were manufactured?

A. As I have stated, they were being manufactured when I went to McQueen's, and were manufactured during the period I was there. This particular package was
355 probably manufactured about the first of 1935; that is December of 1934 or January of 1935.

Q. How do you identify that period?

A. It is dated, the expiration date beyond which it should not be used, as August 1st, 1935. These packages were dated for a period of about nine months.

Q. Was that your general practice—

A. That was.

Q. (Continuing:)—to date all the packages with reference to an expiration date?

A. Yes.

Q. What was the reason for dating those packages?

A. Because the bacteria eventually decrease in numbers to such an extent it isn't safe to use the packages. Some of them might be perfectly good to use several years later, but because some of them deteriorate, some of them, or the storage conditions in which they are kept are not satisfactory, we don't consider it satisfactory to date them for more than one season.

Q. Was that dating of packages due to any deficiency so far as the bacteria itself is concerned?

A. I don't know that I entirely follow the question.

Q. The point is this, Mr. Curie, you said that you
356 dated these packages and that, due to various factors, that they might not be—some packages might be good for two or three years, whereas others might be good for a very short period. Would you just refer to some of those factors you were speaking of that might influence the fact of whether this product is good or isn't after a certain period of time?

A. One thing that is mentioned a lot, although it is not the primary factor, is the by-product the bacteria give off in their life in there which are unfavorable to their own continued growth and gradually cause conditions toxic to the organisms.

Q. Is that common to all bacteria?

A. Yes.

Q. Nothing peculiar to the bacteria you used in this package or product?

A. No. The principal cause of drying off is probably, drying or exposure to excessive heat which is beyond the control of the manufacturer.

Q. You don't have control of the storage conditions and you can't guarantee anything beyond that because of this bacterial life that exists, and you can't control that?

357 A. That is correct.

Mr. Staley: If Your Honor please, I would like to submit this package for identification as Defendant's Exhibit 2.

(Said package entitled "INOCULATION", "McQueen's Inoculator". "Good for Sweet Peas—Lupines, Garden Peas and Beans", was marked Defendant's Exhibit 2 for identification.)

Mr. Thiess: May I see it?

(Package handed to Mr. Thiess.)

Mr. Staley: Q. Mr. Curie, I now hand you herewith some photographs, and ask you if you can identify those photographs, identify the photographs with reference to the package that has been identified as Defendant's Exhibit 2 (handing photographs to witness)?

A. I believe that to be a reproduction of that package.

Q. Those photographs then are accurate reproductions of the package just referred to?

A. Yes.

The Court: Did you mark the photographs?

Mr. Staley: I would like to submit the photographs, two photographs consisting of both the front and back

358 side of the package that has been identified as Defendant's Exhibit 2 to be identified as Defendant's Exhibit 3.

(Said photographs portraying the front and back side of package marked Defendant's Exhibit 2 were marked Defendant's Exhibit 3.)

Mr. Staley: Q. Now, with reference to Defendant's

359 Exhibit 2, which is the package, and Defendant's Exhibit 3, which are the photographs, you previously mentioned that there are four cross-inoculation groups of bacteria culture in this package?

A. Yes.

Q. How did you produce or manufacture the product of the type that is contained in that package?

A. We, as described before, grew the bacteria in these pint bottles containing nutrient agar. To produce this culture we would take a certain number of bottles of peas, bottles of beans—

Q. Just a minute, Mr. Curie. Was the culturing of this bacteria, whether you were culturing that bacteria singly or whether you were culturing the bacteria altogether as a composite group?

A. We were culturing it singly. That is, pea bacteriae were in one bottle and bean bacteriae were in another bottle and to prepare the culture the bottles containing pea bacteriae and bottles containing bean bacteriae, bottles containing lima bean bacteriae and bottles containing lupine, were used in preparing this suspension by washing and scrubbing the growth from the bottles as previously described for a single culture.

360 Q. And you took the individual strains of bacteria from these individual bottles and put them into the suspension, as you call it?

A. Yes.

Q. Will you please proceed then with reference to the continued production of this product?

A. Having this suspension, it was mixed with peat humus, or peat humus, as described before. There is one statement there that might be added. When I went to McQueen's they were using a soil rather than peat humus and some packets contained a soil base rather than a humus base during the season of 1934 and 1935.

Q. Would you consider the two bases more or less interchangeable?

A. No, I would not. The peat humus is a superior base.

Q. In putting the suspension, as you have referred to it, into the humus base of the garden mixture, did you carry over into the base any substantial quantity of nutrient from the culture as it was developed in the test tubes?

A. There was this small amount of nutrient which is removed from the bottle in removing the growth.

361 Q. You have studied the Bond Patent in issue, Number 2,200,532, have you not?

A. I have.

Q. You know Mr. Bond's method of culturing the bacteria and the method of incorporating that bacteria into the humus base, do you not?

A. I do.

Q. What in your opinion as a scientist and as one who is skilled in the art of culturing these bacteriae and manufacturing legume inoculants have you to say with reference to the quantity of nutrient that you carried over into the base of the product that was manufactured at McQueen's and identified as the garden mixture with reference to the quantity of nutrient that would be carried over into a base as established by the method used by Mr. Bond in his patent?

A. I would judge that the quantity carried over by the methods we used would be less than the quantity carried over by the methods used by Mr. Bond.

Q. The actual nutrient that you carried over into the base, if I understand you correctly, is less than that which is carried over into the base by the method established by Mr. Bond?

362 Mr. Rathburn: Is he speaking of McQueen's practice now?

Mr. Staley: Yes.

The Witness: Yes.

Mr. Staley: Q. You also, I believe, know that Mr. Bond uses a humus base, do you not?

A. Yes, he does.

Q. What would you say with reference to the comparison of the base, peat base, as you have referred to it at McQueen Bacteria Company, with reference to the humus base Mr. Bond refers to in his patent?

A. They would be very similar.

Q. By that do you mean that one is interchanged with the other without any different effect?

A. Yes. In fact, at one time we did use peat from the same source they used.

Q. Do you know what that source is?

A. It was stated. Manito, Illinois.

363 Q. Also I believe you know, the method, with reference to Bond's patent, of the manner of individually culturing the bacteria in individual tubes or bottles, whichever it may be, before he mixes them together in the humus, do you not?

A. I do.

Q. Am I correct in stating that you also individually cultured your bacteria before incorporation in the humus of the garden mixture?

A. Yes.

Q. Knowing your own method at McQueen's, and knowing the method of the culturing of the bacteria as set forth in the Bond patent, would you say that the two methods are comparable?

A. They are comparable.

Q. So that the effect on the bacteria by your method would be of no difference from the effect of the bacteria as cultivated by the method set forth in the Bond patent, am I correct?

A. You are.

Q. Did you ever make any tests or perform any tests, I perhaps had better say, with reference to the garden mixture while you were manufacturing that product at
364 McQueen's?

A. Yes, the product was tested in the greenhouse.

Q. Did you apply that product to the various species of bacteria that was specific to the—I mean, apply the species of bacteria that are specific to the various legumes indicated on the packet, Defendant's Exhibit 2?

A. Yes, it was tested on peas, beans, lima beans, and lupines.

The Court: Is lupine a lima bean?

The Witness: It is another of these cross-inoculation groups.

Mr. Staley: The lupine is one of the flowers, your Honor.

The Witness: It is used as a flower largely.

The Court: Is that the name of a specific flower or when you say "lupine" does that cover a variety of different flowers?

The Witness: There are several species of lupines closely related.

Mr. Staley: But that is considered in one cross-inoculation group.

The Witness: It is all in one cross-inoculation
365 group.

The Court: The same as the sweet pea would be?

The Witness: Sweet peas are also included, just as

sweet peas and garden peas are two different kinds of peas.

Mr. Staley: Q. I believe you just stated that you did make some greenhouse tests on the various specific legumes that are specified on the packet?

A. We did.

Q. What would you say was the result of those tests with reference to inoculated or uninoculated plants?

A. The results indicated that the product stimulated the growth in nitrogen fixation of the plants inoculated with the product.

Q. Which method of determining or performing these tests did you use with reference to the product used here? That is, previously you stated you had run both greenhouse tests and nitrogen fixation tests in your experiments, and I was wondering which specific method you applied to this packet.

A. By greenhouse tests in nitrogen fixation, I mean the greenhouse tests indicated that the product stimulated the growth in nitrogen fixation of the plants.

366 Q. What are some of the factors involved in determining the efficiency of bacteria applied to a legume when you are using the greenhouse test?

A. The indication first of increased growth, the color of the leaf in particular. The size of the leaf is also larger with efficient inoculation, and general thriftiness of the plants.

Q. You previously stated that you had run nitrogen fixation tests at various times, am I correct?

A. Yes.

Q. In your experience as a scientist, and one in this field of legume bacteriology, would you say that there is any relationship between the so-called greenhouse test and the so-called nitrogen fixation test?

A. Yes, they are parallel tests.

Q. Just what do you mean by "parallel"?

A. Well, the nitrogen percentage follows the indications according to size and general vigor and color of the plants.

Q. Can one who is experienced in this field of legumes and legume bacteriology indicate or determine, with a fair degree of accuracy, as to the real efficiency of
367 the stimulation to a plant of the various bacteria that are used, so that in his own mind he can know how much nitrogen is fixed in a plant?

A. He can compare between two strains with a reasonable degree of accuracy by the growth of the plants.

Q. What do you mean by a reasonable degree of accuracy?

A. I would say within 10 to 15 per cent.

Q. While you were at McQueen's did you ever run or perform any tests on the individual strains of bacteria that were contained in what you might call your stock cultures?

A. Yes, they were also tested for efficiency in the greenhouse.

Q. Now, you mentioned efficiency and greenhouse in the same sentence. Was it a nitrogen fixation test or just a greenhouse test?

A. A greenhouse test.

Q. So that the test that you ran on the individual strains of these bacteria were of the same kind and type that you ran on the garden mixture, am I correct?

A. Yes, they were.

Q. Would you say that the greenhouse test is an
368 acceptable standard amongst the trade with reference to the stimulation effect that bacteria have upon the plant?

A. Yes, I believe it is.

Q. That, of course, is from your own experience of past years as a scientist in this field, am I correct?

A. Yes.

Q. Did you ever have tests, or perform tests, that were—we will say that extend concurrently, on the single strain of bacteria that were used in the garden mixture, and with the material, the product known as the garden mixture, so that you could see the greenhouse difference between the single strains of bacteria and the bacteria that might be used in the garden mixture?

A. Yes. Quite often we would make, for example, a lot of pea culture in the bottles. Part of these or a number of these bottles would be used to make the mixed culture. Others of the same lot of bottles would be used to make pea inoculation alone, a single culture, and they were therefore tested in the greenhouse at the same time.

Q. If I understand you correctly, then, you say
369 that you took the bacteria from one bottle and made up a single individual culture for peas?

A. Yes.

Q. And you took the bacteria from that same bottle—

A. Not from that same bottle, from another bottle made at the same time and inoculated with the same lot of pure culture.

Q. So the pure culture was identical in the two bottles?

A. Yes.

Q. And that identical culture you used in this garden mixture?

A. Yes.

Q. Now, is that true of each of the strains of the bacteria that you used in the garden mixture?

A. That was true of peas, beans, and lima beans.

Mr. Thiess: This all still refers to the McQueen's garden?

Mr. Staley: Yes, everything in the McQueen's garden up to this point.

The Witness: We did not sell lupines or did not have a demand for lupine culture in itself.

Mr. Staley: Q. Those peas, beans, and lima beans
370 that you speak of are, however, cross-inoculation groups, are they not?

A. They are three different cross-inoculation groups.

Q. And these three cross-inoculation groups were tested by the use of the mixed culture?

A. Yes.

Q. Known as the garden mixture. And you also had comparable tests running at the same time on the individual strains of the same bacteria, am I correct?

A. An individual—or tests running at the same time on an individual culture of peas.

Q. Did you ever notice any difference in the effect of the stimulation on the plants involved when you used the strain of bacteria separately or when you used it in combination with the garden mixture?

A. No, we could see no difference.

Q. Did you conduct experiments to determine
371 whether there was any conflict in the different individual strains and the combinations?

A. The tests were not set up with that idea in mind.

Q. And when you say—I think you said you observed no difference in the growth of the plants. That is a mere observation, I take it.

A. That is an observation on examination of these

plants. In other words, we have two tests running in the greenhouse at the same time. If there is a noticeable difference in those two tests, if we are on our toes, so to speak, in our examination, we would see differences which are apparent in the growth of those plants.

Mr. Staley: Q. With reference to the garden mixture again, what can you say as to the numbers of bacteria that went into the garden mixture?

A. We attempted to put them in in approximately or substantially the same numbers for each of the different groups.

Q. How did you do that?

A. From time to time we ran counts on the number
372 of bacteria in one of these bottles and for different groups, in this way: We established a general average of the number that could be expected in those bottles. The peas and beans run approximately the same number. The lima beans will run a somewhat larger number.

Q. What was the reason for that?

A. Well, just common experience in growing them, that usually in a lima bean culture you will have a larger number of bacterial cells than you do in peas or beans. It is nothing that we are attempting to do, it is simply the reaction and as they grow on the same agar base.

Q. Would you say that any two of the cross-inoculation groups in this mixed culture are, using the words of the Bond patent, in the same order of magnitude?

A. The numbers that we put in there were in the same order of magnitude.

Q. This garden mixture, as I understand it, in the packet form and identified as Defendant's Exhibit 2, was to be sold to gardeners, am I correct?

A. Principally used by home gardeners.

373 Q. Did you ever make any other mixed product besides garden culture?

A. We also put that same culture up in a larger package for use of the commercial truck garden grower who grew produce, vegetables, and in this case it would be peas and lima beans, for sale on the city markets.

Q. I now hand you a photostat, a positive photostat, of an advertisement of the McQueen's Bacteria Company, and ask you if you can identify that photostat?

The Witness: That is a reproduction of the price list issued by the McQueen's Company in the summer of 1937.

Mr. Staley: I would like to offer in evidence the two sheets of photostats and identify them as Defendant's Exhibit 4.

(Said photostatic copy of sheet of advertisement and the photostatic copy of Wholesale Price List, effective July 15, 1937—Season 1937-38, of McQueen's, 374 Inc., Baltic, Ohio, in re McQueen's Seed Inoculants, etc., were thereupon marked as Defendant's Exhibit 4 for identification.)

Mr. Thiess: If your Honor please, this is an advertisement of McQueen's, and with respect to anything—there are many statements of boasting and so on. I object to that. The only part of the advertisement that is pertinent would be those that are established by facts on the advertisement. In other words, any statements as to what this garden culture will do, as contained in conclusions in this advertisement, are merely conclusions in the boasting statements, and we object to those upon that ground.

The Court: The exhibit may be received with that limitation. That is the first exhibit that you have offered?

Mr. Staley: I am offering it only for identification at the present time. I would like to submit it for identification only and then we will offer all of the exhibits at one 375 time, if your Honor please.

Mr. Staley: Q. On Defendant's Exhibit 4 do you find any indication of the market size that you just referred to?

A. Yes, it is pictured on the first sheet at the middle of the right-hand side, market size inoculator for fifteen pounds of seed.

Q. Do you have any way of telling when that advertisement was put out?

A. The first sheet is dated July—or the second sheet here, which to us was the front of the advertisement, is dated July 15, 1937, and was issued at about or slightly before that time.

Q. You were at McQueen's at that time?

A. I was.

Q. These advertisements were available to you?

A. They were.

Q. You knew of the market size inoculator that was put out by McQueen's at that time?

A. I did.

The Court: It was given general circulation, was it, by McQueen's?

376 The Witness: Yes, it was distributed to the seed trade.

Q. You have heard Mr. Bond's direct testimony with regard to the use of bacterial inoculants in the field as compared to bacterial inoculants used in gardens, have you not?

A. I have.

Q. What have you to say with reference to the market size product in this same relationship?

A. This was used for commercial growing just as much as a farmer uses the other groups for raising crops for profit. The market gardener's cash value of produce per acre rates high in comparison with the normal field value of profit per acre, so I would say that that was an important use and an important product.

Q. Now, after you left the McQueen's Bacteria 377 Inoculant Company, of Baltic, Ohio, I understand you went with the Agricultural Laboratories, Inc., of Columbus, is that correct?

A. I did.

Q. You had control over the methods of manufacture, did you, or did you not?

A. I was associated in the production of the products at that time. I was not in complete control of it.

Q. You knew of the products that were being manufactured?

A. I did.

Q. Did the Agricultural Laboratories, Inc., manufacture any mixed culture at the time you went with them in the fall of 1937?

A. They were manufacturing a garden culture also.

Q. Would you please state as to the manner in which this garden culture was manufactured?

A. It was manufactured by preparing the cultures in the same way as elsewhere disclosed, except that the base used was a finely powdered charcoal rather than a peat humus. Otherwise the method of production was 378 similar.

Q. With reference to the mixed culture and the gar-

den grouping, what did the mixed culture that was manufactured by Agricultural Laboratories, Inc., include as to cross-inoculation groups?

A. It contained different pea, bean, lima bean, and lupine groups.

Q. You have mentioned that the Agricultural Laboratories product contained a charcoal base. What have you to say with reference to the nutrient value in a charcoal base with reference to that in a peat base?

A. Very much less nutrient value.

Q. In the manufacturing would you give in a little more detail the steps of manufacture of the mixed culture of the garden variety that was made at Agricultural Laboratories, Inc., at the time and just shortly after you went with them, with reference to the manner of incorporating the bacteria into the base?

A. At the time I went there we—I take it you are
379 referring to the preparation of culture suspension and the mixture with the base.

Q. That is correct.

A. We took bottles which were growing one cross-inoculation group, and that would be bottles for peas, bottles for beans, bottles for lima beans and bottles for lupines, and washed the growth from the surface of the agar in those bottles into a suitable container forming a suspension of bacterial cells.

Q. Was that incorporated in the charcoal?

A. And that suspension was then incorporated with the charcoal base.

Q. What have you to say with reference to the quantity of nutrient that was put into the charcoal base as a result of the method that was used at Agricultural Laboratories, with reference to the method of putting the bacteria into the base as set forth in the Bond patent?

A. The simple washing of the growth from the agar would carry over less nutrient than the method used and disclosed in the Bond patent.

Q. Would you say that the base of the garden mix-
380 ture produced at Agricultural Laboratories, using the charcoal base, was, using the words of the Bond patent, substantially free of bacterial nutrients?

A. As interpreted in the Bond patent, yes.

Mr. Thiess: Well, now, I object to that unless he says

what his interpretation is. We don't know what his interpretation is, and I move to strike it.

The Witness: My interpretation of that is that the suspension prepared according to the Bond patent, in which he carefully breaks up the agar and allows it to stand for a period of 24 to 36 hours, dissolves out soluble mineral materials and sugars contained in this agar, and that is carried into the peat humus base, which peat humus base carries sufficient material to establish the growth of the bacteria in that base; while with the other procedure, in which the water is poured into the bottles, scrubbed off and poured out again within a period of a few minutes, there will be a small amount of nutrient dissolved and the charcoal contains a small amount of potash but the other nutrients are substantially lacking.

The Court: Q. Which method is the more desirable?

381 A. We have at the Agricultural Laboratories changed over so that we are using a mixture of peat and charcoal as the base, because we have found to our satisfaction that that produces a better base than either one alone.

Q. Yes, but which is the better method of getting the growth from the agar, the method described by Mr. Bond that you just told about or the method you use? You said you get less nutrient in the method you use.

A. I prefer the method I use.

Q. Well, it would be advantageous to have all the nutrient possible in the base, wouldn't it?

A. No. Well, the nutrient isn't the main reason I do not like that method.

Q. Oh.

A. These bottles are allowed to stand for a period of 24 to 36 hours after that growth is washed loose. Now, there are foreign bacteria that do multiply rapidly in such a suspension, regardless of the presence of the legume bacteria, and there is a considerable number of foreign bacteria carried over into the peat after that procedure.

382 Q. Well, that is the reason you do not prefer that method?

A. That is.

Q. I thought you were emphasizing the fact that you got less nutrient in your method than in the other.

A. No, that is not my reason for preferring the other method.

Q. The other method, in that respect at least, would be desirable, then, wouldn't it, so far as the nutrient question is concerned?

A. Yes, it would not be undesirable.

Q. And the Agricultural Laboratories, Inc., now uses a combination base of charcoal and peat, do they?

A. Yes.

Q. In all of their products?

A. Yes.

Q. This package here, marked Defendant's Exhibit 1, has charcoal and peat?

A. Yes, there is a mixture of peat and charcoal.

Mr. Staley: Q. That change, however, was made when?

A. About 1939.

Q. After the date of the Bond patent, which is August 24, 1938?

A. I believe so.

383 Q. Did you ever test the garden mixture of Agricultural Laboratories, Inc.?

A. Yes; that mixture was tested in the greenhouse.

Q. By the same methods previously described?

A. Substantially the same methods.

Q. What were the conclusions, the results of your tests?

A. The conclusions were that the combination produced satisfactory stimulation of plant growth on the various plants that were supposed to be inoculated.

The Court: These were greenhouse tests, you say?

The Witness: Greenhouse tests.

Q. (By Mr. Staley) Mr. Curie, previously you stated—

Mr. Thiess: As I understand it, those are greenhouse tests you conducted of garden culture?

The Witness: Yes.

Mr. Thiess: At Agricultural Laboratories.

The Witness: Yes.

The Court: Pardon me. How long has the Agricultural Laboratories been putting out the combination or garden package?

The Witness: They were putting it out at the time I went with them, in October, 1937, and I don't know how long before that time.

384 Q. (By Mr. Staley) Do they still continue putting the garden culture out?

A. They do.

Q. Mr. Curie, you mentioned the fact earlier in your testimony that you had recently run or performed some nitrogen fixation tests. Would you please state what those tests were?

A. They were tests of individual strains of clover bacteria alone and in mixture with strains of alfalfa bacteria.

Q. I now hand you herewith a typewritten sheet of figures and ask you to identify that sheet (handing paper to the witness).

A. This sheet is a summary of the most recent test conducted.

Q. (By Mr. Staley) Can you tell me when those tests were made?

A. They were begun October 27, 1944.

Q. Can you tell me the circumstances under which those tests were run, and why they were run?

A. They were run to determine whether or not we
385 would find inhibition of efficiency of clover bacteria, as affected by the presence of alfalfa bacteria in the same mixture.

Q. Do you know if these tests were run after the filing of the Complaint in this case?

A. They were.

Mr. Staley: If your Honor please, I would like to present the original and have it marked Defendant's Exhibit No. 5.

(Said Summary headed: Efficiency of Clover Bacteria as Affected by Alfalfa Bacteria, and dated October 27, 1944, was marked Defendant's Exhibit No. 5, for identification.)

Q. (By Mr. Staley) Now with that sheet of figures in front of you, Mr. Curie, Defendant's Exhibit which has been identified as Defendant's Exhibit 5, will you please explain to the court the manner in which those tests were made, and what they mean?

A. These tests were set up for greenhouse in quart Mason jars, common quart Mason jars. These jars were filled to about an inch from the top with quartz sand and then watered with a nutrient solution containing the
386 necessary mineral elements for the growth of the bacteria, with the exception of nitrogen.

There were—

Mr. Staley: Pardon me just a moment, Mr. Curie.

Q. (By Mr. Staley) Were these tests run under sterile conditions?

A. After these jars were filled and watered a capsule was placed over them, and they were sterilized under 15 pounds of steam pressure for a period of two hours, so they were run under sterile conditions. After the jars had cooled they were arranged in sets or rows of five jars.

Q. What do you mean by sets of five jars?

A. On the greenhouse table five jars were placed in each row and in these jars as surface sterilized or disinfected clover seed was planted in each jar, approximately 10 to 12 seeds per jar.

After the seeds were in the jar they were inoculated by adding a suspension of the bacteria which we were proposing to test. That is, there was a row of five jars that was inoculated with clover bacteria, Strain 201.

Another row of jars immediately adjacent, was inoculated with an equal amount of this same clover strain mixed with alfalfa culture.

387 After they were inoculated the seeds were covered with a layer of dry sterile quartz sand and allowed to grow in the greenhouse. The same as described for Strain 201 was set up for each of the 12 strains listed here and then one suspension prepared mixing all of the clover strains together, a row inoculated with that, and another row, this clover suspension containing all strains mixed with alfalfa and a row inoculated with that mixture.

The Court: Did you have a row inoculated only with the alfalfa strains?

The Witness: We did not. This is a test of clover plants.

A. (continued) They were allowed to grow in the greenhouse and after about two weeks' time the plants were up and were showing growth, whether they were going to be normal plants.

At this time the small plants were thinned down to five plants in each jar to have comparable numbers in all jars.

They were then allowed to grow; they were watered as moisture was depleted in the jars and maintained for a period of from two to three months.

The Court: Did you apply this solution with the
388 bacteria more than one time?

The Witness: One time only at the planting of the seed.

A. (continued) At the end of this period, or after a period of some two months, photographs were taken of the jars and then the jars were harvested—

Q. (By Mr. Staley) Just a minute, Mr. Curie,—I don't like to break in at this point but you have the test of October, 1944 in your hands?

A. I have the test of October, 1944. These plants were harvested by cutting the top growth at the surface of the sand and drying it to constant weight in an oven and then determining the total nitrogen content of the five plants in each jar. The results are summarized on this sheet.

The Court: Just tell me: Is there any appreciable difference in the various series of pots?

The Witness: In plant growth, yes; there was marked difference in the growth of the different series of pots.

Mr. Staley: With reference to that point, your Honor, I would like to submit to the witness at this point some photographs he just mentioned with explanation.

The Court: All right.

389 Mr. Staley: And for identification I would like to put these photographs in and identify them as Defendant's Exhibit 6-A to L, inclusive.

(Said photographs, showing two rows of five jars in each row on each photograph, with plants therein, with heading above top row of Clover, heading in middle between rows as follows: Clover Bacteria 202, 2A1, 2A2, 2A3, 2A4, 2A5, 2A6, 2B1, 2B2, 2B3, and 2B4; and heading: 12 Strains Clover Bacteria; heading below the bottom rows of jars on each photograph as follows: Plus 12 Strains Alfalfa Bacteria, was marked Defendant's Exhibit 6-A to 6-L, inclusive, for identification.)

The Court: Defendant's Exhibit 6-A to 6-L, inclusive, is a series of photographs of the plants involved in the test just being testified about?

Mr. Staley: That is correct, your Honor.

Q. (By Mr. Staley) Now, Mr. Curie, I hand you the set of photographs which have been identified as De-
390 fendant's Exhibits 6-A to -L, inclusive, and ask you if

you can identify the photographs and explain these photographs with reference to the test that you have just mentioned.

A. The photographs were taken of these various series of various tests. In each picture are the five jars in each test. The first one shows—

Q. Mr. Curie, will you please refer to the strain numbers on the photographs as you refer to them, so that we can identify the exhibits as you go through, specifically?

A. The first picture refers to the clover bacteria strain 202 and the bottom row is this same clover strain plus a mixture containing 12 strains of alfalfa bacteria.

The Court: The first five jars are supposed to be the same?

The Witness: Yes; they were treated alike.

The Court: They were treated alike?

The Witness: Yes. And the bottom row was treated alike.

The Court: And inoculated?

The Witness: Yes; they were inoculated similarly.

Q. (By Mr. Staley) Was that with a single or with a mixed culture?

A. The upper row is the single strain, clover alone.
391 The bottom is the same clover strain mixed with alfalfa.

Now in this picture there is very little difference from the picture between the strain with or without the alfalfa present.

An analysis of weight per jar shows a difference of twenty milligrams.

393 A. (continued) The pictures as we may run through them: 2A1, the clover bacteria alone, to my eye, appear to be definitely less growth than the clover bacteria plus alfalfa; 2A2 shows poorer growth and very variable growth of the clover alone where this variation is not evident where the alfalfa is present.

2A3—

Q. (By Mr. Staley) You are speaking of strain numbers, aren't you?

A. Strain numbers on the picture. The next picture which is labelled as Clover Bacteria 2A3 shows variable growth in the clover alone but better than some of those earlier, and in this case the 12 strains of alfalfa bacteria also shows variation.

2A4 shows poor to fair growth of the clover bacteria alone and a definitely better growth when the alfalfa bacteria are present.

2A5 shows growth from poor to probably fair in the clover bacteria alone and the 12 strains plus the clover is variable but at a higher level.

In 2A6, four of the jars are very poor. The other one I would say showed obviously that there was a contamination by air borne means of another strain of clover bac-
394 teria.

To consider the results properly it is not fair to throw out because we think there is something wrong with it, when we don't know what the cause of the trouble is. So therefore, whether it agrees with the rest or not, I still leave that in there to take the picture.

The over-all comparison, the bacteria where the alfalfa is present, the growth is much better.

And the next picture, Clover Bacteria 2B1, shows decided variation where the clover is alone and rather good growth where the alfalfa bacteria are also present.

In the Clover Bacteria 2B2 we have two rather good jars and three poor ones. Again the variation is not nearly so great where the alfalfa bacteria are present with the clover.

2B3 shows four out of five have good growth of clover alone and similarly four out of five, good growth when the alfalfa is present.

Clover Bacteria 2B4 shows poor to fair growth when the clover is alone and rather good growth when alfalfa bacteria are also present.

The last picture shows a mixture of all 12 of these clover strains, in the upper section showing wide
395 variation in growth of individual jars and the lower picture where the alfalfa bacteria were mixed with this clover suspension shows very good growth throughout.

Now, from the series of pictures it appeared to the naked eye inspection that the alfalfa bacteria certainly had not reduced the growth of the clover and the effect of the clover bacteria but over-all, seemed to definitely improve the growth.

This test as has been noted, was begun October 27, 1944, and ran through November and December, which, while it was in the normal light of the year, is a rather low light

level, and no artificial light was used in growing these plants.

That may be a factor in the wide variations exhibited in the top section. I don't know what the variation is.

Q. Nevertheless, this laboratory procedure is standard practice, is it not?

A. It is.

Q. You previously mentioned that you harvested the crop after a certain period of time?

A. Yes.

Q. Did you subject the crop that you got off of these various jars to statistical analysis?

396 A. I did.

Q. Is that statistical analysis a part of the report that you have included in the Defendant's Exhibit 6?

A. It is; the result is the statistical analysis as indicated on the report.

Q. That is Defendant's Exhibit 5?

A. Yes.

Q. As a bacteriologist and scientist in the field of legume bacteriology, would you say that there has been any indication of inhibition?

A. No; there is no indication of inhibition. There is no strain among the 12 that shows a significant reduction in growth as judged by appearance, weight, or nitrogen fixation.

Q. To your knowledge, Mr. Curie, do you know of any reputable scientists in America, or in any other part of the world, as far as that goes; within your own knowledge, that ascribes to the theory or the fact that one strain of legume bacteria is inhibited when it is put into association with another strain of bacteria of the legume variety?

A. With the exception of the patent disclosure here I know of no reputable scientists in this country who

397 subscribe to a theory of inhibition.

Q. Do you confine your answer to this country?

A. Not necessarily.

Q. Mr. Curie, is the test data that you have just been referring to and which data has been compiled in Defendant's Exhibits 5 and 6, the only nitrogen fixation test that you have run?

A. It is not. I ran a test beginning in January of 1944, previous to this test.

Q. I now hand you herewith a report that for purposes of identification I would like to identify as Defendant's Exhibit 7.

(Said document entitled: The Effect of Alfalfa Nodule Bacteria Rhizobium Meliloti on the Activity of Clover Nodule Bacteria Rhizobium Trifolii, by I. H. Curie, was marked Defendant's Exhibit 7, for identification.)

I will ask you if you can identify that report and tell us what is in it.

A. This is a report of tests run to determine the effect of alfalfa nodule bacteria on the activity of clover
398 nodule bacteria. These tests were set up on January 7, 1944.

Q. Did you run these tests yourself?

A. I did. These tests were set up as were the later ones, by planting red clover seeds in quart Mason jars containing sterile quartz sand supplemented with all essential mineral nutrients except nitrogen.

They were inoculated as indicated below, which is substantially as is described in the other experiment.

Q. Was the inoculation carried forth in the same manner as in the other experiment?

A. It was. The preparation was substantially as in the other test.

Q. What did the results of this test show?

A. The results in this test show, beginning with Clover 201 alone, which culture was isolated, that is, put into pure culture, in agar culture, from a nodule, in 1922 or earlier.

Q. Mr. Curie, before you go any further will you identify these strains of alfalfa and clover bacteria in connection with the subsequent report you made?

A. They are the same 12 strains used in the subsequent report.

Q. You may now proceed.

399 A. This 201 clover alone gave a plant weight per jar of 242 milligrams. When alfalfa was added the weight was 420 milligrams of nitrogen.

The effect of the alfalfa was a plus 158 milligrams. That is a significant increase indicated by the presence of the clover strain.

The Court: Your experiment on the 201 clover on the other experiment is just the opposite, isn't it,—it shows a minus?

The Witness: Yes. In other words, there were variations in the strain itself between these two times.

The Court: Is that the way you account for the variation in the single clover strain itself?

The Witness: Yes.

The Court: What do you mean by the isolated in the year 1922? I didn't get your information on that.

The Witness: This culture was obtained— They were either obtained from the University of Wisconsin or from the United States Department of Agriculture. Our records show that this culture has been in their collection since 1922. In that year it was either isolated from a plant, from a nodule on a plant, or selected from some culture.

The Court: Did you use the same culture in the sub-
400 sequent experiment shown on Exhibit 5?

The Witness: Yes, it is a transfer of the same culture.

A. (continued) Now Strain 202,— In this case the Strain 202 was selected in 1935. In this case there was a loss of 116 milligrams as the effect of alfalfa. This loss is statistically significant.

As we go through the group of them we find 2A1 had an increase but the increase was not sufficient to be termed significant. It may have been due to chance.

2A2 showed an increase which was significant. 2A3, isolated in 1922—

The Court: 2A1 showed a plus 98 and was not significant and 2A2 was significant and that was 82.

The Witness: The variation among the five jars—that is the purpose of the statistical analysis. The variation among the five jars in 2A1 was decidedly more than the variation in the five individual jars, in 2A2.

Therefore, because they varied, as some of these in the pictures varied more than others, that variation was sufficient, that we couldn't say whether that gain of 98 in 2A1

was due to these variations or was due to the pres-
401 ence of the alfalfa bacteria, while in 2A2 the differences among individual tests was not great and the statistical analysis indicated that that difference was not due to chance but was due to the presence of the alfalfa bacteria.

2A3 shows a decrease of 62 milligrams but the difference is not significant. 2A4 shows a significant increase, 2A5 an increase, but not significant; 2A6 shows a slight increase entirely without meaning.

2B1 shows a slight decrease similar to 2A6 but in this case a decrease again entirely without meaning; 2B2 also a slight decrease. Note that both 2B1 and 2B2 were isolated in the 1920's.

2B3 shows an increase of 62 milligrams, a significant increase. 2B4 shows a very slight decrease; no significance.

Considering the averages that is, our averages of these 12 series,—the clover alone as compared to the clover plus alfalfa showed an increase of 39 milligrams where the alfalfa was present but this difference was not sufficient to say that the over-all comparison was significant.

The Court: In other words, you wouldn't be justified in reaching the conclusion that the addition of alfalfa
402 helped the product?

The Witness: No, but this—but you certainly could not say that it was inhibitive.

The Court: All right.

Q. (By Mr. Staley) Mr. Currie, have you analyzed the statistics in the Bond patent, No. 2,200,532?

A. I have checked the figures.

Q. Would you say, as a scientist and as one skilled in this art, that the statistics in the Bond patent show or demonstrate the correctness of a basic principle, concept or theory, whichever you want to call it, of inhibition of one strain of bacteria relative to another when it is placed in association with the other strain of bacteria?

A. In analyzing the statistics given in the patent I would not say that inhibition was demonstrated.

Q. Do you agree or not with the statement of Mr. Bond in his patent, on page 2, column 1, line 74, wherein it states:

"—this has not been done"

and that is with reference to mixed culture now we are speaking

"—because it was generally believed that one species produced an inhibitory effect on another species within
403 the same culture whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented"?

A. No, I would not agree with that statement.

Q. Would you agree with the statement that, quoting from the patent:

> "It was for this reason it was considered desirable to use a culture containing a single species of organism rather than one containing a mixture?"

A. I would not agree with the statement.

Q. Mr. Curie, I now hand you a chart that I would like for you to identify, and with reference to that chart, analyze it with respect to the Bond patent and at this point I would like to first submit the chart for identification as Defendant's Exhibit 8.

(Said document entitled: Bond Patent No. 2,200,532; Nitrogen Fixed Per 10 Plants Clover, etc., was marked Defendant's Exhibit 8 for identification.)

Q. (continued by Mr. Staley) Now, Mr. Curie, with Defendant's Exhibit 8 in your hands, would you explain what those various columns and figures on there mean
404 and analyze that chart with reference to the statistical data that is given in Mr. Bond's patent No. 2,200,532, on page 6, first column.

A. This chart was prepared from the figures given in the last column of Mr. Bond's table on page 6 as to the milligrams of nitrogen fixed.

The Court: You mean in the first column?

The Witness: Yes, in the first column. When I said last column I was referring to the last column in the table rather than in the sheet of the patent, as the column entitled Milligrams of Nitrogen as per 10 plants.

The Court: Oh, I see.

A. (continued) These columns on the chart represent the best possible agreement,—the least possible variation Mr. Bond could have had between the individual jars in his tests.

Q. (By Mr. Staley) Let me ask you, first, Mr. Curie: Why did you use five columns in these various groups?

A. We used five columns because the patent states there were five jars in each test he produced and that the results were based upon the results of the five jars.

So we have drawn a column indicating the amount of nitrogen fixed in each jar, giving the most favorable
405 light that is possible from the standard deviation quoted.

The first column under Number 2, Non-Selected Strain represents the average. The next two columns under Number 2, represent the average plus the standard deviation.

Q. What do you mean by standard deviation?

A. That is the figure that Mr. Bond has given as his statistical analysis of his result. That is the variation of the standard deviation from the mean.

406 Mr. Staley: Q. What do you mean by "standard deviation from the mean"? Was it something up or down, or what?

A. That is the amount up or down from the average. It is a term used in statistical analysis. The two 125.5s represent the base yield of two of the jars.

The 105.5s represent the average minus, the standard deviation that he quotes.

Now, these differences might have been more among some of these, but that is the most—the closest agreement that he could have had.

On the next set, the five columns under "No. 3", the Selected Strain, the average nitrogen fixed was 140.3.

The last two represent the average minus the standard deviation, and is 108.7.

Column No. 4—

Mr. Staley: Just a minute.

Q. Mr. Curie, will you explain what that little green thing means on top of those columns?

A. Well, these two strains, while the differences were within the standard deviations, as he mentions it, the average differences in those two, that is the difference
407 between 115.5 and 124.5, No. 3, was 9 milligrams higher in fixation originally than 115.5. So if we want to make further comparisons, we must or should balance this original difference out of the equation.

Q. In other words, No. 3 had a head start on No. 2?

A. To begin with, I think it had a handicap, in other words, of 9 milligrams over the No. 2 or non-selected strain.

Going on to No. 4, which represents the non-selected strain plus alfalfa, the average was 74.3, the two columns of increase were 78.2 and the two columns showing the decrease or the minus deviation was 70.4.

Now, going over to No. 5, we have this selected strain plus alfalfa. The average here was 119.5. The deviation

was wider in this than in the others, which meant that the average plus the deviation went up to 159.2 and the average minus the standard deviation was 79.8. Now, if we balance out this 9 milligrams of difference between the two strains originally—

Q. The difference between two strains? Which ones are you speaking of?

408 A. Between 2 and 3, since 3 showed 9 milligrams higher fixation than 2, that difference should be subtracted from the fixation in 4, if you really want to compare.

Mr. Greer: Pardon me. I think you meant 5.

The Witness: Yes; if you want to compare 4 and 5.

So, if we take this 9 milligrams from this low yield of 78.8, we have a figure of 70.8 which is lower than the average he reports for the non-selected strain plus alfalfa. It is practically the same as the low figure that he has on No. 4. Now, this standard deviation meant that the two average might have been as high as or as low as he has indicated.

Therefore, in comparing 70.8, that might have been the true average in this test 5 when the difference between original strains was balanced out.

Therefore, to use No. 4 or No. 5 there would have been no difference in the actual quality of a culture produced, by using either one of these strains in combination with alfalfa. There might have been— The variation is within a limitation of error of experiment.

Mr. Staley: Q. If I understand you correctly, then, the probability of the deviation as set forth by Mr.
409 Bond's figures in his own patent, is such that by that laboratory deviation you could probably expect an average yield in No. 5 as well as 70.8?

A. You might expect a yield that low or you might expect a yield as high as 159.2. You might.

Q. Is there any way of guaranteeing one or the other?

A. There is not.

Q. Mr. Curie, what might you expect with reference to the unselected species when put in association with the alfalfa?

A. You might expect as low as 70.4 or as high as 78.2.

Q. Are the variations comparable?

A. Well, the variation in 4 is very much less than in 5, indicating that this strain 5, the selected plus alfalfa might give quite variable yields in the field.

Q. Mr. Curie, you were in the court room at the time Mr. Bond testified that while not directly employed by Agricultural Laboratories, yet he had been connected with them at one time or other?

A. He had—

Mr. Neuman: He did not so testify, that he had been connected with them.

Mr. Staley: Or at least he had been to the plant 410 or had some association with the personnel.

Mr. Greer: We accept the record. He testified that he was never connected with it; he visited them but never was connected with them.

Mr. Staley: Q. Do you know when Mr. Bond was at Agricultural Laboratories, Incorporated, at Columbus, Ohio?

A. I can't determine the actual days. It was early in June 1941.

Q. How do you establish that day or those days?

A. He was there a week or so preceding the seed trade convention of that year, which was held during the latter part of June, and further, I established that by a letter which I had written regarding that visit.

Q. I hand you herewith a letter written to Dr. H. W. Bachelor, Ohio Agriculture Experiment Station, Wooster, Ohio, and it has your name I. H. Curie at the bottom of the letter, and I ask you if you can identify that letter?

A. That is a carbon copy of a letter sent to Dr. Bachelor, on June 30, 1941.

Q. Did you write the letter?

A. I wrote the letter.

411 Q. That is a carbon copy, is it?

A. That is a carbon copy.

Q. Where has that carbon copy been since the date on the letter?

A. It has been in my correspondence file at Agricultural Laboratories.

Q. When was it removed from that file?

A. Immediately preceding this case at Quincy.

Q. And if I take you correctly, the carbon copy of that letter has been in your possession since the date it was written until it was removed from the file for purposes of use here?

A. It has.

Mr. Staley: I would like to present the letter that has just been identified by the witness, as Defendant's Exhibit Number 9.

412 (Said carbon copy of letter dated June 30, 1941,

addressed to Dr. H. W. Bachelor, Ohio Agriculture Experiment Station, Wooster, Ohio, from I. H. Curie, was thereupon marked as Defendant's Exhibit Number 9 for identification.)

The Court: Is the purpose of the letter just for fixing the date of Bond's visit?

Mr. Staley: For fixing the date of Bond's visit.

The Court: Maybe there is no question about it. When was it?

Mr. Rathburn: He said it was in June, 1941.

Mr. Staley: There is another point involved we want to establish with reference to this mixed culture, by this letter.

Mr. Greer: If they will admit that—

Mr. Staley: If they will admit that he was there in June—

Mr. Rathburn: Yes, he admitted it was in June, 1941.

Mr. Greer: He testified about June. The matter of whether it was the first or last part of June becomes essential, as we will show later on. Do you care to admit?

Mr. Staley: Do you care to admit that it was the
413 first part of June or the last part of June?

Mr. Varley Sherman Bond: I don't recall the part of June it was.

Mr. Rathburn: On the basis of that letter, we will admit that it was the first part of June.

The Court: All right.

Mr. Greer: The first part of June.

Mr. Rathburn: Will you let me look at that letter again? I missed the date on it. I am sorry. I thought the letter was dated early in June. It says June 30th. We don't know when it was.

Mr. Thiess: The letter is dated June 30th, which is the last part of June, so I don't think that we will admit he was there the first part of June. Maybe Mr. Bond can check it up.

The Court: Q. When was he there with reference to the time you wrote this letter?

A. He was there several weeks previous to the time I wrote this letter.

Q. You say that he was at your plant in June and you say several weeks previous to the 30th of June. Is that as near as you can fix this time?

A. Yes. I do know that this seed trade convention
414 in St. Louis intervened between the time he was there and the writing of this letter.

The Court: All right. Proceed.

Mr. Staley: Q. Mr. Curie, with reference to the Legume-Aid product, Plaintiff's Exhibit Number 1, which is the mixed combination culture of alfalfa and clover, can you state when that combination mixture was first produced and distributed by Agricultural Laboratories, Incorporated, of Columbus?

A. It was first produced— the first mix was made in December, 1940 and the goods was shipped out during January and February of 1941.

Q. Do you find in the letter that has just been referred to as Defendant's Exhibit No. 9 any reference to the mixed culture?

A. Yes.

Q. (Continuing:) Of alfalfa and clover?

A. There is reference to this mixed culture.

415 Q. You state that the mixed culture was introduced in December, 1940, to the seed trade?

A. It was sent out— or manufactured in December, 1940, and sent out in January and February, 1941.

Q. How do you establish that particular period of time of December 1940?

A. Because it was the year preceding the time that it was generally placed on the market and as a matter of fact, that letter was further corroboration of the time.

417 Mr. Staley: Take the witness, Mr. Thiess.

418 *Cross-Examination by Mr. Thiess.*

Q. Doctor Curie, I understand that after you left the Ohio University, you started in to work on agar culture bacteria, and so forth, at a state experimental station, is that correct?

A. That was Wooster College, my undergraduate work, not Ohio University.

Q. No. I mean after you got through with the University work?

A. I had already been employed at the Experimental Station seven years when I got my Master's Degree from the Ohio State University.

Q. What was the character of work that you did at that agricultural station?

A. We carried on various experimental work in the fields of soil bacteriology or soil biology, as it is termed.

Q. Well, can you specify what the type of work was, more specifically?

A. Yes. A good part of my work, in the first few years I was there, was devoted to the study of another nitrogen fixing bacteria which lives free in the soil
419 and not associated with the legume.

Q. And that was research work on that particular bacteria?

A. That was one of the things that I worked on.

Q. And what else did you work on?

A. As I stated, beginning in 1926, on the legume bacteria.

Q. Well, what was the character of the work that you did on the legume bacteria?

A. We, in 1926, carried on field experiments on the effect of fertilizing soy beans, the effect of this fertilizer on the nodulation and nitrogen fixation of soy beans. That was the first work.

Q. In other words, that was an investigation to determine the effect of fertilizer—

A. Yes.

Q. —in the field?

A. Yes.

Q. And did you do any other work in this—

A. Beginning in 1927 or '8 we began to test the commercial cultures, that is the products of the various companies which were selling inoculants in Ohio.

Q. And what inoculants did you test?

420 A. We tested Nitragin. Dickinson's—

Q. Will you give the trade names of these, if you know them, if you remember them?

A. Nitragin, of course, is a trade name.

Q. Of what company?

A. Of the Nitragin Company.

Nodogen is the product of Albert Dickinson Company. We tested also the products of the McQueen's Bacteria Company. This was known as McQueen's Inoculant.

There were others, some of which I can name and some of which I would not remember.

Q. Will you give me all that you remember?

A. There was Scott's Bacteria U NEED-R Inoculant. That was spelled U-N-E-E-D-R, as I remember it. And I am not sure of the first year. There was a Dry-Inoc put out by the Franklin Laboratories. We did test Urbana Culture Product of the Urbana Laboratories.

That is all I would want to state definitely. There may be others.

Q. And were these cultures all of the garden variety?

A. No. They were not all of the garden variety.

Q. Which ones of them were of the garden variety?

421 A. I do not know that any of those tests at the experimental station were of the garden variety.

Q. And were they all of single cultures?

A. Those named were, yes.

Q. They were all single cultures.

And you tested no garden variety of mixed cultures while you were there?

A. Not at the experiment station.

Q. And these tests that you made at the experiment station, were any of them nitrogen fixation tests, that you made at the laboratory?

A. If you mean by "nitrogen fixation tests" nitrogen analysis—

Q. Yes.

A. —there were nitrogen analyses run on some of the tests, on some of the results of the greenhouse tests.

Q. In these tests did you use control pots?

A. Yes. There were always control pots used.

Q. In other words, it is necessary, to run a proper test, to use a control pot, is it not?

A. We do use control pots.

Q. Will you kindly answer the question? Is it necessary, to get good results?

422 A. Yes, it is.

Q. Subsequent to this work that you did in the laboratories, I understand that you obtained a Fellowship at McQueen's, is that right?

A. I had my Fellowship financed and established by McQueen's.

Q. By McQueen's, and this Fellowship was where?

A. It was jointly at the Ohio Agricultural Experiments Station and the Ohio State University.

Q. What was the character of the work that you did while you were working on this Fellowship?

A. It was entirely work on the legume nodule bacteria.

Q. And what specifically was the work?

A. Well, it was a search for a good base or the best base that we could find.

Q. By that you mean the base to mix the medium in which the bacteria are placed?

A. Yes.

Q. In the inoculant?

A. Yes.

Q. And what was the result of this investigation? What did you find to be the best base?

A. As a result of that investigation, none of the 423 bases that McQueen's wished me to work on were satisfactory.

Q. And what were those bases, that were unsatisfactory?

A. The base that they were using was soil. We made various amendments to soil, by means of adding peat moss for one. I don't remember all of these any more.

Q. Well, give me, to the best of your recollection, the ones that you remember?

A. And one that we added was peat pulp.

Another was a mixture of peat with soil.

I believe there were several brands of peat moss and peat in there.

Q. And none of these were satisfactory, as I understand?

A. None of them were fully satisfactory.

Q. And as a result of that, what did you recommend as a satisfactory medium because of the work that you did on this Fellowship at Ohio?

A. I recommend—

Q. What did you recommend at the time?

A. I recommended that they go to an all-peat base.

May I amend the work of this Fellowship?

Mr. Thiess: All right.

The Witness: It was set up by McQueen's that 424 they wanted to use and that they wanted me to work on soil plus such amendments as might be found to improve it as a carrier. These various amendments, some of them did improve the soil as a carrier, but they did not meet what I thought was necessary to produce a good inoculant.

Q. And what was the medium that you finally recommended?

A. Peat humus.

Q. Peat humus alone?

A. Yes, that is, as treated with limestone, if an acid peat.

Q. Now, you were employed by McQueen's for how long?

A. For a period of somewhat over three years, from June 1934 until October 1937.

Q. And while you were employed by McQueen's, did McQueen's put ont any composite culture outside of the garden culture that you refer to?

A. No.

Q. And did they put out a single culture?

A. Yes, they did.

Q. Did they recommend and sell this single culture for field use?

A. They did.

Q. And the garden culture that is put out was sold
425 for garden use, was it not?

A. Garden and market gardens or truck gardens.

Q. And do you know why they made that distinction between the garden culture and the field culture, in that in the field culture they used the single species and in the garden culture they used a plurality of the species of the various bacteria?

A. That was a matter for convenience, for the user, I would say.

426 Q. Well, what do you mean by the convenience of the user?

A. Either a home gardener or the market gardener frequently wishes to plant peas, beans or lima beans and, therefore, for their particular use they liked this mixed culture. It was impossible to sell the home owner a separate culture for each one. Therefore, they were combined. The market gardener also found that combination desirable and wanted it in quantities to satisfy his needs.

Q. Well, if the mixed culture or garden type would be satisfactory for field use, wouldn't the farmer have been just as anxious to get the combination culture?

A. A mixture of peas and beans?

Q. Well, a mixture of the particular types of plants he was interested in.

A. No, not at that time.

Q. Why do you say "no, not at that time"?

A. Because the use of the mixed seedings had not grown, the demand for mixed seedings, as you call it, pasture mixtures, I call it hay mixtures, was not as wide spread as it developed later.

Q. I am not talking about pasture mixtures alone. I

am talking about inoculating seeds for fields and large acreages of these various legumes.

427 A. If a farmer wanted to inoculate alfalfa he bought alfalfa inoculant. If he wanted to inoculate clover, he bought clover inoculant.

Q. It is your position if the farmer at that time had been told he could get a combination culture of alfalfa and clover, he wouldn't have been interested?

A. Not unless he was sowing these mixed seedings I have referred to.

Q. I would assume, of course, he had been sowing these mixed seedings. Is it your position as an expert in the art that the farmer would not be interested in a combination culture at that time?

A. He may have been. I don't know.

Q. Don't you believe he would have?

A. No, I don't see why—

Q. He is today, is he not?

A. For mixed seedings.

Q. Also for use on his field cultures, is he not?

A. The farmer accepts the mixed cultures. He doesn't care, if he has ten bushels of alfalfa seedings, he is not interested in the clover in that package. He would just as readily buy a can labeled alfalfa only.

Q. In other words, it is your position that as far

428 as this art is concerned, they were not interested in a mixed culture for field use such as charged to be infringed here at the time we are talking about or the present time?

A. Who do you mean by "they"?

Q. I mean the farmer or the distributor or the manufacturer.

A. The distributor probably would have been.

Q. Well, how about the manufacturer?

A. Possibly so.

Q. Wouldn't you say absolutely so?

A. Yes, I would say the manufacturer would have said so.

Q. So that, as I now understand you, there was a real demand for one of these mixed cultures at the time you were working for McQueen, that is for field use, and no such culture was produced by McQueen?

A. I refuse to accept your statement.

Q. What is your statement? What would you say to that?

A. My statement is we had no request for such culture from the jobber, dealer or farmer.

Q. And are you of the opinion that there was no desire for such a culture?

A. There was none evidenced.

Q. I asked you whether you are of the opinion there was no such desire.

429 A. I know of no such desire.

Q. Then, as I understand you, it is your position that this mixed culture for field use, that is charged to be infringed and which is disclosed in the Bond patent in suit, wasn't used prior to Bond's—the issuance of Bond's patent because there was just no desire for it? Is that your position?

A. It is not.

Q. What is your position?

A. My position is that a majority of the single cultures at that time were none too good. It was difficult enough to produce a good single culture.

Q. When you say a lot of single cultures were none too good, which ones are you referring to? Will you please name them?

A. Oh, innumerable ones.

Q. I want you to be specific and give me the names of the single cultures that were none too good.

A. This U-Need-R wasn't generally satisfactory.

Q. What other ones? Give me all you know of that were not satisfactory.

A. McQueen's wasn't entirely satisfactory.

Q. What others?

A. There were Earp-Thomas single cultures which were not satisfactory.

430 Q. Any others?

A. There were Dickinson humus cultures which were not satisfactory.

Q. Give me all you can remember. Any more?

A. The early Dry-Inoc was not satisfactory.

Q. Any more?

A. There was a Mulford agar culture which wasn't generally satisfactory. That is, I believe, all I can name from memory.

Q. Can you give me any that were satisfactory?

A. Yes, there was Dickinson's Nodogen, an agar culture.

Q. That was a single culture?
A. Yes, on agar.
Q. Any others?
A. This Urbana culture, an agar culture.
Q. That was satisfactory?
A. Within the limits—it was satisfactory from the standards of that day. The Nitragin culture was satisfactory.
Q. Any others?
A. The Scott's bacteria was satisfactory.
Q. Who made that culture?
A. I don't know who made it. It was distributed by the Scott Seed Company.
Q. And those were single cultures?
431 A. Those were single cultures.
Q. Now, you had satisfactory single cultures on the market, some of them, as you have enumerated?
A. There were a few.
Q. And you were telling me when I broke into your answer that, as I understand it, that the reason that this composite culture didn't get on the market was because it was difficult with single cultures?
A. Yes.
Q. Will you continue with your answer, please?
A. These cultures were satisfactory on the basis of that day. I doubt if they would pass the more rigid test requirements of the testing laboratory today.
Q. When you say satisfactory as to the requirements of that day, will you be just a little more specific as to what you mean by that?
A. The tests used at that time in the various States were tests for nodulation only in general.
Q. And tests for nodulation are not satisfactory as to present standards?
A. Not completely, no.
Q. Nodulation doesn't tell you whether you are getting good results or not?
432 A. It doesn't guarantee you are getting good results.
Q. It merely tells you you are getting nodules?
A. That you have bacteria of the species named.
Q. Well, now, I wish you would explain again in just as few words as you can why you believe the mixed culture was not of any value in the early part or was

not demanded and then suddenly became in demand sometime around 1940.

A. A little earlier than that.

Q. All right, a little earlier than that. Tell me about it.

A. While I was with the Ohio Experimental Station it became the recommended practice of the men of that Station, staff, to recommend that any farmer who was planting clover seed should mix some alfalfa seed with that clover.

Q. You say that was a recommendation when?

A. It came along about 1930, I should judge, that their field results at the Experimental Station indicated it was a good practice, and they so recommended.

Q. How did they recommend it? Was that ever published?

A. Yes, I believe those reports are published.

Q. Can you refer me to any of those reports?

A. I cannot.

Q. Then it is purely a matter of recollection on your part at the present time?

433 A. At the present time, yes.

Q. That they made recommendations at that time to do what?

A. To mix alfalfa and clover seeds.

Q. All right. Will you continue with your story?

A. The result, as I observed in the field, that in place of having a crop of clover from which the farmer gets one good crop and then he gets a second crop, and that is all from the clover, if he mixed alfalfa seed with that, his first cutting looked principally like clover. There was some alfalfa in it. His second cutting of hay that same year would show a substantial increase in the proportion of alfalfa and, if he had been successful in getting a stand of alfalfa, he would have a third cutting and might keep that over for a second year or even a third.

This was recommended as a way of establishing alfalfa seedings which had been difficult. Therefore, it was recommended, and as is pretty well known, the farmer is a rather conservative individual, he doesn't always grab onto things in a hurry, but year by year there was an increase in the amount of these mixed seedings and at a meeting at the Experiment Station—this was after my day there—of the Ohio Seed Dealers Association, one of the members of the staff made a statement that sur-

prised me in stating that ninety per cent of the hay seedings are mixed seedings, that is, they contained
434 more than one kind of seed, and in these seedings were usually alfalfa and clover—there may have been several varieties of clover—and quite frequently some timothy.

In fact, a general recommendation was a seeding of four pounds of alfalfa seed, four pounds of red clover seed, four pounds of timothy seed and two pounds of Alsike seed. Of this mixture of seed—there is fourteen pounds—ten pounds of it is legume seedings, alfalfa and clover.

Now, it was generally recognized it was necessary to inoculate alfalfa seed if there was going to be any expectation of getting a stand.

Q. You say "it was generally recognized". On what do you base that?

A. Well, by farmer experience and Experiment Station work, they knew if they didn't inoculate, and bacteria wasn't present in the soil, they wouldn't get this stand I have been referring to. Clover had been grown for years. They would get a crop of clover. Checking up with various farmers indicated they would get an increase in the yield of red clover if they inoculated this clover, not a big increase necessarily, but one that would give them a very good return for the money invested in the clover seed.

435 Q. That would be very, very desirable, would it not?

A. Yes, it would be highly desirable.

Q. Continue with your story.

A. Consequently, most farmers inoculated the alfalfa, or they might think it was too much trouble and plant it anyway and fail. Very few would go to the trouble of buying a can of alfalfa inoculant and another of clover inoculant and inoculate the alfalfa seed and inoculate the clover seed and then mix them altogether.

Some farmers, however, would buy a can of each of the inoculants, mix the two inoculants together, and then inoculate the seed. In that way, the farmer was mixing inoculants and, so, by the time of 1939—I am speaking of Ohio where I am best acquainted—a very substantial part of the hay mixtures or pasture mixtures were mixed seedings and the mixed culture situation was a definite economic prospect.

Q. When did you say this was being done, this farmer mixing these two and putting them into the seed?

A. That occurred among farmers of my acquaintance as early as 1932.

Q. Well, in view of your story, you knowing about this, why was it that you never recommended to McQueen's or had them make a mixed culture of this kind so the
436 farmer would have a mixed culture?

A. I stated when I went to McQueen's, they were using a soil base which wasn't entirely satisfactory. It took me sometime to get the production of McQueen cultures switched around to where we had a good product. In fact, I had my hands full up until October 1937 that I was certain I had a good single culture and knew it had plenty of organisms in it.

Q. I understand you knew in 1932, about this advantage, the farmer mixing these things together as the farmer did, and the inconvenience that was resulting to the farmer from buying one or the other. There wouldn't have been any difficulty under those circumstances, if you knew about this, to suggest, "Why, we will mix these two together in a common culture", there wasn't any difficulty about it?

A. I have stated it was difficult to produce a satisfactory single culture and if you take two, a doubtful quality alfalfa culture and mix it with a doubtful quality clover culture, I have grave doubts of the value of the result-
437 ing mixture.

Q. In other words, they have got to be pretty well selected, these strains?

A. Not only that but they have got to be put into a pretty good base.

Q. But if the base is satisfactory for, say, an alfalfa culture, it would also be satisfactory for a clover culture, would it not?

A. Yes, it would.

Q. So, if you had an alfalfa strain in the base, it wouldn't necessarily affect the culture if you put clover in it, if the two would operate together satisfactorily with the proper selection?

A. Except the question of composition for the material in it to grow on. I have stated that McQueen's didn't have a satisfactory base. In other words, for each bacteria in the culture at that time, it would be my judg-

ment that there is a hundred in a culture of today. That may not have applied to the jelly culture.

Q. Well, you had your base in 1937, did you not, your satisfactory base?

A. Well—

Q. Did you make a recommendation at that time, 438 with a satisfactory base, to combine these two?

A. In 1937 I left McQueen's.

Q. Did you make a recommendation to anybody?

A. I did not.

Q. So that, you made no recommendation to combine these two at any time until after the Bond patent had issued, is that correct?

A. That is not correct.

Q. What is correct?

A. It is correct that I made such recommendation or suggestion in 1939.

Q. In 1939?

A. Yes.

Q. And what was that recommendation and to whom did you make it?

A. Not as a direct recommendation but as a suggestion that this seeding mixture would make such a product desirable and that it would be well for us to start work on such a product.

Q. And who did you make that recommendation to?

A. To Mr. Elmers and Mr. Erickson. I don't know necessarily whether I made the original suggestion or Mr. Erickson; I can't say which of the three of us did.

Q. And Uni-Culture was on the market at that time?

439 A. Uni-Culture was on the market at that time.

Q. Now, as I understood you, and I want you to correct me if I am wrong—did you say that the strains of clover and alfalfa that you have in your Legume-Aid are strains that you have been using for years?

A. Some of them are. Not all of them. Some of them.

Q. How many of them are?

A. I would say that three of them have been.

Q. Three of what?

A. Three of the alfalfa.

Q. How many of clover? Give me a statement on both of them.

A. Two or three of clover have been in use or have been isolated prior to 1938.

Q. How long prior to that?

A. I would have to check individual records to see when I obtained each culture in the collection or when it was isolated.

Q. You say three of the alfalfa?

A. I wouldn't limit myself to three. Two or three.

Q. Of both clover and alfalfa are old ones?

A. Yes.

Q. And how many of them are new ones?

A. As a matter of fact, there are none of them
440 new ones. There is one clover I isolated in 1938 and one in 1941 that may enter into our present cultures only.

Q. Then you have got five clover strains in your present culture?

A. No, I said two or three.

Q. Now, I don't think we understand one another. I would like to have from you how many clover strains which are in your present culture that you have used before you made this culture, old strains that you used in your single culture?

A. I do not limit myself to exactly the same strains at all times.

Q. Then you can't answer my question?

A. I use—there are four strains in clover, according to one greenhouse test that I find, and I may use three of those older strains and one new one or based on a more recent test until I have another test run, on the basis of new information—if I find a new strain that is better than what I have, I begin to use that new strain.

Q. And you have been changing these strains?

A. I have from time to time and expect to continue to do so.

Q. Both of your alfalfa and clover?

A. Yes.

Q. And you are doing that to improve the Legume-Aid culture?

A. I am.

441 Q. And where did you get these new strains from?

A. They are strains that I isolate myself in the majority of cases now. I may get a strain from Wisconsin or a strain from the Department of Agriculture. I am not—

Q. Well, do you go out in the field and get some of them?

A. Yes.

Q. And do you know whether or not some of these strains that you obtained in that way were strains that were the result of clover or alfalfa that had been inoculated with the Uni-Culture?

A. No, I do not.

Q. You don't know whether that was true?

A. I don't know of any strain that I have that—

Q. You don't know whether that is true or not?

A. No. The only clover that could—that has been isolated since the time of that patent was selected from clover plants along the roadside near Columbus, and the chances of that having been inoculated with a commercial culture are very slight.

Q. And how often have you changed your strains in this Legume-Aid? Do you do it every year?

442 A. Every year the recheck is made on the basis of the latest greenhouse tests. I may or may not change. If I have a combination that in my mind appears better—if one of my old strains has lost its vigor I will quit using it and use one that appears best at that time.

Q. Have you found a lot of strains that lost their vigor?

A. I have found a substantial number of strains that have.

Q. How many strains have you found that lost their vigor?

A. Oh, over my whole collection—

Q. I mean, since you have been working on these strains of this Legume-Aid that you took out because they lost their vigor that you talked about, how many of those?

A. I have probably discarded three or four clover strains from actual use.

Q. Because of their loss of vigor?

A. Because of their loss of vigor at that time.

Q. And how many alfalfa strains?

443 A. No alfalfa strains have been thrown away out of our collection. I suppose I have changed strains two or three times there.

Q. How many did you change because of loss of vigor in the characteristic of the strain?

A. I can't answer in a definite number, because that is done according to each test, each greenhouse test.

Q. Well, what I am particularly interested in, Mr. Curie, is to know since you put the Legume-Aid on the market how many strains of clover and how many strains of alfalfa you discarded because they lost their vigor?

A. And I can only say that I have changed the strains.

Q. You told me, did you not, that you took some of them out because they lost their vigor.

A. Yes, I have.

Q. Now, can you tell me how many you did take out on that basis?

A. I have stated that I cannot tell you exactly how many. I could by going back through the years of laboratory records.

Q. Well, can you say that there were a large number of them, say, five or six of each?

444 A. No.

Q. Or ten?

A. No, I would say two or three of each.

Q. That is your best approximation at the present time?

A. Yes, out of a total of eight or ten that have been used all told.

Q. Now, in the Legume-Aid that you make, do you make an efficiency test of the strains that are put into that before it is put on the market?

A. Those strains are made approximately once each year.

Q. Those tests, you mean?

A. Yes, the tests are made.

Q. And in that efficiency test do you make a test on the basis of nitrogen fixation?

A. On the basis of nitrogen fixation as evidenced by plant growth.

Q. In other words, you do it purely visually?

A. Not purely visually, by visually and plant weight.

445 Q. Then you do actually make tests, do you?

A. I do.

Q. To determine the amount of nitrogen that is fixed in the strains that you want to use, compared with the control plant?

A. Yes, I do.

Q. You always have a control plant?

A. I always have.

Q. And do you make any tests when you combine these

strains, before you put them in your culture, to ascertain whether or not there is any antagonism between the strains?

A. I do not, because I have never recognized such antagonism.

Q. You make no tests of that type at all?

A. I do not.

Q. Now, did you say that you have tested the mixed culture?

A. Yes, I have.

Q. And did you test that mixed culture in an efficiency test as compared with a single culture?

A. You are speaking of the finished?

446 Q. Yes.

A. Yes, I have.

Q. And did you find a difference in the results that were obtained when you ran these tests between the single culture and the mixed culture?

A. I did not.

Q. You found no difference at all?

A. Not in stimulation of plant growth or fixation as indicated by plant appearance, and plant weight.

Q. And that is the result of—

A. That is within the limits of error, as we determine it. No two tests will give exactly the same result.

Q. Well, within what limits of error do you place that?

A. Within this statistical error as used in here, which is the standard test indicating odds of nineteen to one. That is, the differences are not due to chance.

Q. Now, if I remember correctly, did you say that you could determine what amount of nitrogen is fixed, by observation, to the extent of 15 per cent?

447 A. I can tell whether the plant weight and the total nitrogen,—I believe I can estimate to that extent.

Q. Anything over 10 or 15 per cent?

A. In a difference of plant weight.

Q. Over 10 or 15 per cent, is that right?

A. Yes, I believe so.

Q. Now, would you want to say unqualifiedly, as an expert in this art, that you could do that, that you could say that there wasn't a difference of 25, or 20 or 30 per cent, without actually making a test and weighing it?

A. No, that error might run up to 20 per cent. Of

course, the only way a person could do that would be by repeated trial.

Q. The only way to find out is by weighing, is it not?

A. Weighing is the preferable way, although you do get within 20 per cent.

Q. You think you can get within 20 per cent?

A. I think I can.

The Court: Q. There was something said on the other side about an inhibitive strain in these plants, and
448 a non-inhibitive strain, and you don't feel that there is any such a thing as those two?

A. No, I testified that I have no belief in an inherent inhibitive action of one strain.

Q. Over another.

A. Because it is an inherent characteristic in the strain. There may be times when the yield will be down. I have one instance here in my own work in which the difference was low. The next time, that same strain, there was no appreciable difference, so whether to class that as an inhibitive strain or a non-inhibitive strain—because those tests do vary from one time to another.

Mr. Thiess: Q. Now, if I remember your testimony, you described tests of garden mixtures which you made while you were with McQueen's, and, as I understand it, those were purely visual tests.

A. Those were visual tests.

Q. And you enumerated there that you would do that visually by an increase of growth, the color of the growth, and what was the other one?

A. The size of leaf, which is also in general the
449 growth and color characteristic.

Q. In other words, your visual inspection is the size of the plant and the color, is it?

A. Yes; and, let us say, accurate with a plus or minus 15 per cent.

Q. And that is what you mean by plant inspection and growth inspection?

A. Yes.

Q. Visual inspection, I should have said. Now, as I understand it, you said you also made tests on a single culture in the garden mixture and compared that with using the mixed garden mixture as a culture, is that correct?

A. Yes. As I explained, we may have made a single

culture and a mixed culture from the same lot of bottles, in which case the culture would have been tested.

Q. And did you test those to compare them?

A. Only by this visual inspection, which, I may add, is the criterion used by most of the state testing agencies and also by the United States Department of Agriculture.

450 Q. They rely entirely upon the visual test, do they?

A. Most states rely on those.

Q. Which states, particularly?

A. New York, I believe, does. There are not too many states. Oh, the tests that have been run in Ohio were on that basis.

Q. And they do not make the nitrogen tests?

A. Not regularly.

Q. Well, they do make them if they want to be real accurate, don't they?

A. Yes, there are times that they are made. The United States Department of Agriculture uses this visual test.

Q. And uses the visual test for what purpose?

A. To check the relative efficiency of different cultures on the market.

Q. And you say they do not use the nitrogen test at all on the test of those efficiencies?

A. To the best of my knowledge the United States Department of Agriculture does not.

Q. And is it your contention that among scientists that is contended to be a proper and satisfactory test,

451 the visual test?

A. That would be indicated inasmuch as these tests are for the efficiency of the cultures, whether they gave satisfactory results or not. I would assume that they thought that they were.

Q. Well, do you believe personally that they give satisfactory results so that you can rely upon them to the extent of saying to the farmer, "You are going to get as good results out of this particular culture as you do out of another culture"?

A. Within these ranges.

Q. Well, you deem within a range of 20 per cent. That is a real range so far as the farmer is concerned, isn't it?

A. In most cases not too much so.

Q. In other words, you think the farmer is not interested in that last 20 per cent?

A. Oh, that is an increase. It is a worthwhile increase.

Q. That is what I am talking about.

A. But we are talking of clover here. For example—may I use a crop of clover as an example?

Q. Clover.

452 A. An average clover crop on fairly good land will run a ton and a half to two tons per acre.

Q. When you say on fairly good land, that means the average farm in this section of the country?

A. Yes, average or something above that, which is the type of farmer that inoculates.

Q. Well, wouldn't it be even more essential that the man that had the inferior farm should inoculate?

A. Unfortunately that is the reason he has the inferior farm, because he hasn't learned not only this but other modern farming practices.

Q. All right. Well, now go on.

A. In this clover affair that I have been interested in, I felt that if I could show a farmer a 10 per cent or less increase in his hay crop I would be doing him a good turn. If he had two tons of hay per acre and I could step it up 10 per cent, to 4400 pounds, if he got 400 pounds of clover hay from spending the price needed to inoculate the quarter bushel or less of seed that went on that acre, he has a very good return for his money. These wide differences that have been used for years to talk inoculation are rarely seen in the field, and I

453 have had one case called to my attention in the field where a farmer doubled or more than doubled his yield by inoculating clover. That was a farm—one of these that you were speaking about just now, that had been run down, and then the man put on phosphate and potash fertilizer and inoculated some of his field and some he did not. He did not have this big response that is publicized so much, and this publicity has been bad for the inoculant industry as a whole, because this 10 per cent increase that 95 per cent of the farms might get is not the one that shows up, but over the country would give a big increase in crop.

For the past two years—well, let's finish this. Now, here, if this man—I am talking of a 400 per cent increase, or a 10 per cent, 400 pounds.

Q. 10 per cent, yes.

A. Thank you. If he had a culture that was 90 per cent as good as that, he would lose 40 pounds of clover hay. Well, that is a loss, but he has that 360, and
454 under field conditions no one can control the result of the inoculation to that extent. During the past two years the American Soy Bean Association has been advertising strongly to the soy bean growers of the country to inoculate, and one year they publicized the fact that if one bushel per acre increase of soy beans was obtained by inoculating, the yield of soy beans over the country would be increased by a tremendous amount of bushels.

One bushel of soy beans would cost the farmer 10 cents to inoculate. One bushel of soy beans is worth a couple of dollars. So he has a good return. I have emphasized that sort of increase myself rather than these—I have seen one case where they inoculated soy beans that yielded ten times as much as the uninoculated. Well, now, to go out and advertise that generally and lead a farmer to think that he was going to double or triple his crop is misleading.

Q. Well, I was talking primarily about this 20 per cent.

A. Yes.

455 Q. And that 20 per cent is worthwhile, as I understand it, according to what you have just said.

A. This case that I have just quoted, if we take 20 per cent, the man has, without adding further bacteria to his soil, has two tons, or 4000 pounds.

Q. Per acre.

A. Yes. In one case he would have 400 pounds and in another—you say 20 per cent, which I put as the absolute limit, the average would be substantially under that—if he had a 20 per cent, it would be 80 pounds. Yes, that is worthwhile, but as compared to the general increases it doesn't rank up in the way of stating 20 per cent of the man's total crop, because his clover crop is not going to be a failure if he does not inoculate at all. We are talking in terms of total crops, of 20 per cent.

Q. But if there is that difference in two inoculants it would be worthwhile to use the inoculant that gave you the extra 20 per cent, 10, 15 or 20 per cent.

A. If that difference is significant and will be repeated.

Q. That is right.

A. You say 20 per cent. My own figure is 10, 15;
456 in other words, 40 pounds.

Q. I thought you said 10, 15, and it might go up to 20.

A. Yes. You quote one extreme and allow me to state my own minimum of 10.

Q. I am taking it over the entire average. Now, these tests that you made on the garden mixture with the single strains with single strains of some of the bacteria in the mixture at McQueen's and where you tested it visually, you haven't got any records on that, have you?

A. No, I do not have.

Q. This is your best recollection of that?

A. Yes. In other words, we never noticed differences between the two.

Q. And that is purely a proposition of recollection on your part at the present time?

A. That is.

Q. Now, you also referred to the fact that you made a count of the number of bacteria in the garden culture made at McQueen's. That is correct, is it not?

457 A. In the bottles used in preparing that culture, garden culture.

Q. Well, how did you make that count?

A. By the standard plant test, Petri dish.

Q. And do you remember what that count was as to each one of those bacteria?

A. Within a reasonable range.

Q. Well, give me the best of your recollection, will you?

A. The clovers would run up to around 300,000 per pint bottles.

Q. Can you give it to me in bacteria per cubic centimeter?

A. No, because I measured it on the basis of the count in a bottle.

Q. You never got the number per cubic centimeter, or we could calculate that from the bottle. It is a pint bottle, is it?

A. Well, that is the total in this bottle which has a slope of jelly in there. It is a pint bottle. There is less than one-fourth of that capacity of agar. It is in terms of the surface, not in a volume comparison there at all.

458 Q. Well, did you make any count of the bacteria in the solution?

A. No, we did not.

Q. You never made any count of that?

A. No.

Q. So you did not know how many bacteria you would actually have in the solution that you added to the humus, or whatever your medium was in your garden culture.

A. Not in one individual lot. We were basing our run on the average number of bacteria that we had in the bottles.

Q. Well, then you had no accurate count of how many bacteria there were in each one of these legumes of mixed garden culture?

A. No accurate count.

Q. Well, you have referred in your direct testimony to the manner in which you made this garden culture at McQueen's. That is correct, is it not?

A. Yes.

Q. Now, are there any written records as to how this was done?

459 A. There are not.

Q. This is also a matter of your recollection?

A. Simply a matter of following the standard procedure.

Q. And your recollection as to how it was done?

A. Yes.

Q. Now, you ran some tests—let me put it this way: What were the first tests that you referred to? Did you run some tests at McQueen's?

A. On what?

Q. Tests comparing the strains of these bacteria?

A. The individual strains before they were used in the culture?

Q. Yes.

A. Yes.

Q. You haven't got the record of those tests?

A. No.

Q. Now, then the next set of tests that you referred to, if I remember correctly, were the tests that you ran at the Agricultural Laboratories, is that correct?

A. Yes, I have run further tests there.

Q. Now, what was the first set of tests that you ran and that you have referred to in your testimony at

460 the Agricultural Laboratories, do you remember?

A. The first set of tests I run?

Q. The first tests that you described in your direct testimony.

A. Well, that is again the comparison of the garden mixture as compared to a single culture prepared at the same time.

Q. And you ran a test of that kind at the Agricultural Laboratories?

A. Yes.

Q. Have you got the data on those tests?

A. I do not have.

Q. Is it available anywhere?

A. No, it is not, I don't believe.

Q. So whatever you have told us on that is also a matter of your personal recollection only?

A. That is.

Q. Now, as I remember, the next tests that you ran were the tests on strains of clover and alfalfa, alone and in combination, which tests were run for the purpose of this suit, is that correct?

A. That is correct.

461 Q. Have you got the data on those tests?

A. I have.

Mr. Thiess: I will ask counsel if he will kindly produce this data so that we can have it for inspection at further cross-examination.

Mr. Greer: I have no objection to producing them at all.

462 IN THE DISTRICT COURT OF THE UNITED STATES
Southern District of Illinois
Southern Division

Q. Mr. Curie, do you remember that you told Mr. Bond in 1941 that you were not able to find any inhibition in tests which you conducted on mixed cultures?

463 A. I do not.

Q. You don't remember making any such statement?

A. No.

Q. You don't remember talking to Mr. Bond about that at all?

A. No, not in regard to inhibition tests.

Q. Now, referring to the tests which are tabulated on

Defendant's Exhibit 5, did you use uninoculated control pots in these tests?

A. What is the number, Number 5?

Q. Here (handing paper to witness).

A. Yes; there was a series of uninoculated controls.

Q. Do you have any pictures of these uninoculated control pots?

A. I do not.

Q. And why didn't you take any pictures of those?

A. Because the plants had died or were in a dying condition and were so low that they couldn't be seen above the rim of that jar.

Q. And that was true of each and every one of them?

A. Yes; there may have been one that would have been to the level of the top of the jar.

Q. And you made absolutely no effort to have a
464 pictorial representation of those available?

A. No, I didn't have them photographed.

Q. Now, have you given us the test data on these control pots?

A. The test data?

Q. Yes.

A. Yes.

Q. The test data on the control pots is included in the data you gave us?

A. Yes.

Q. Can you point out where that is in the data that you gave us?

A. Row 28.

Q. Which one? Will you point it out to me?

A. Check (witness indicates on document).

Q. Row 28. That is your control pot?

A. Yes.

Q. And will you do likewise for this set of data?

A. In that set of data as in the report submitted the plant growth was so low and the plants were dead at the time, that it was impossible to harvest outgrowth from them and accordingly there was no growth taken on those controls.

465 Q. So you had no data on your control to compare it with at the end?

A. I had no weight record. Those reports are weight of tops.

Q. Now, the ones that you have no control records on

are the ones in which the data is tabulated on Defendant's Exhibit 7?

A. Right.

Q. Now you stated, as I understand it, that one pot in this series, 2A6, was probably contaminated with a good strain. That is correct, is it not?

A. Probably.

Q. And if that is the fact, how do you know that the jars in the lower series of that picture were not also so contaminated?

A. In comparison with this, one of them may have been.

Q. How do you know that more of them may not have been?

A. Because in any series of this sort the principal use that I have for controls is to check your percentage of contamination.

We all do have controls which do get bacteria in them from external sources beyond our control and those will happen and therefore we have those controls to see
466 whether those do appear.

Q. But in this picture, Defendant's Exhibit 6-G, the jar in the upper row which you say was contaminated, according to my visual inspection is about the same as the ones in the lower row, is it not?

A. It may have been contaminated is my statement.

Q. If that has been contaminated, isn't it possible that you have got the growth which is in the lower rows about the same by the same contamination?

A. It is beyond all limits of probability that such a thing would happen.

Q. But you don't definitely know?

A. One chance in a million, I would say, or less.

Q. You will admit that as far as a visual inspection goes, the growth on that one plant that you say is contaminated in the upper row is about on a par with the better plants in the lower row, is that correct?

A. Approximately so.

Q. Now, what training, if any, have you had on the application of statistical analysis to figures of this kind?

A. I have had no course work in such.

Q. And to what extent have you used this statistical analysis? What do you know about it?

467 A. I have used some of the older types, before 1933.

Q. What method of statistical analysis did you use in analyzing the results in the tests of Defendant's Exhibit 5?

A. What is known as Student's method.

Q. And can you just explain generally what that method is?

A. It is a method— I do not pretend, let me say, to be a specialist in statistical analysis as I have stated.

Mr. Thiess: I appreciate that.

A. (continued) This T test, Student's T test, is the term used, is a method by which you compare the standard error between the two means under comparison with the difference between those means, and the result is expressed in the odds that such difference did not occur by chance.

Q. (By Mr. Thiess) And do you know of any place where that test is used for statistical analysis in biological work?

A. It has been used to quite a degree.

Q. You know that it has?

A. I have seen it used.

Q. Do you know of any scientific laboratories that use it? Could you tell me any that you know of? Do
468 the universities use it for this work in biological determinations of statistical analysis?

A. It is used in certain types of work at Ohio State University.

Q. And what was the standard error of your determination in applying this statistical analysis?

A. The standard error is not written out in the run thru the formula. The formula expresses a ratio.

Q. So that this does not give a standard error and you haven't given it to us in the table?

A. No; it is not given in the table.

Q. And you would not know what the standard error would be in applying your test?

A. I did not calculate standard error individually in this case. I can do so.

Q. Now, in the tests that you submitted in Defendant's Exhibit 5, I understand they were only conducted on clover, is that correct?

A. That is correct.

Q. Did you make any tests on mixtures on alfalfa plants?

A. We did not.

Q. Can you tell me why you did not?

A. Limitation of time and labor available for tests.

469 Q. It would be just as essential to conduct the tests of alfalfa as it would be on clover, would it not?

A. If there is such a thing as inhibition. Pardon me; if you want the standard error of the difference, they are here.

Mr. Thiess: Thank you very much.

Q. (By Mr. Thiess) Now, on Defendant's Exhibit 7, does not the test on Strain 202 demonstrate significant inhibition between clover and alfalfa? Have you got that exhibit up there?

A. I have it right here. It shows a significant reduction in yield when alfalfa is present in this test run at this time.

Q. Well, that does show that there is inhibition,

470 does it not?

A. No, it does not.

Q. Why not?

A. Because in the other test of the same strain at a different time under different light conditions no inhibition appears. There is no significant difference between the averages.

Q. And which is the other strain on this test that shows that?

A. Exhibit 5, I believe.

Q. Which one is that, on Exhibit 5?

A. Strain 202.

Q. The second one from the top?

A. Yes.

Q. That is the one you corrected?

A. Yes.

Q. And you say they were run under different conditions. What are the different conditions under which these two were run?

A. Time of the year—

Q. Is that all?

A. —which constitutes a very different condition in the light to which these plants were exposed, for one thing.

471 Q. In other words, one was started when, that is, Exhibit 5?

A. In chronological order, Exhibit 7 was started on January 27, 1944.

Q. And ran until when?

A. Ran for slightly over two months.

Q. And with respect to the one on Exhibit 5?

A. That one was started October 27, 1944.

Q. And ran until when?

A. That one ran for about three months, to approximately the end of January.

Q. And you have used the same strains of both clover and alfalfa in both of those tests?

A. As explained in the first one the alfalfa was a mixture of four strains which we use in manufacturing our culture.

Q. In the first one, that is the one on which Exhibit?

A. Exhibit 7.

Q. Yes; and the one on Exhibit 5 used how many strains?

A. 12 strains.

Q. And did the 12 strains in the test on Exhibit 5 include the four that you used in the run on Exhibit 7?

A. They did.

472 Q. And you wouldn't say that the addition of these other strains might have caused that inhibition rather than the light? You don't believe there is any possibility of that, is that correct?

A. There was no inhibition in the second test where the 12 strains were present.

Q. When you took out some of those strains and used four of them, you did get inhibition?

A. No, the first test was run with four strains.

Q. Yes.

A. The first test was run with four alfalfa strains present and we had this reduced yield on Strain 202.

Q. Yes.

A. In the second test 12 strains were included and no inhibition occurred.

Q. And even though you made that change between the two, you don't think that that had anything to do with the difference in results, that this difference in results is due absolutely to light; is that your position?

A. I absolutely do not say the difference is due to light. That is a great difference that occurs at that time, different seasons of the year. The same 4 strains were present in both tests. Other strains were put in in
473 the second test.

Q. Then you do not know at the present time definitely why that difference occurred?

A. I do not.

Q. Now, is it your opinion that scientific work in this biological art in connection with bacteria for inoculating legumes outside of this country is of no value?

A. No; it is of value.

Q. And isn't it true that the original discovery of legume bacteria and their practical use was made by a German investigator?

A. It is true.

Q. Then would you consider that the publication by Mr. Kronberger that has been put into evidence, is not valid?

A. Not because Mr. Kronberger is a German nor anything of that sort, but I do not believe that Mr. Kronberger has proven inhibition.

Q. In other words, you feel that the data that is contained in his paper does not show or prove inhibition?

A. That is correct.

Q. In other words, you interpret the paper as not showing inhibition?

A. I do.

474 Q. Now, referring to this Defendant's Exhibit 8, am I correct in saying that the columns represent conjectural data and not actual measurements?

A. Mr. Bond did not submit his original figures. Those are the most favorable interpretations that can be given his results.

Q. Those are conjectural interpretations you gave to his figures?

A. They are.

Q. Do you understand how the law of the standard deviation of the mean is determined?

A. Yes, I believe so.

Q. Can you just generally tell me how that is done?

A. Through two ways which reach the same place. The one method is by subtracting each individual determination from the mean and then squaring—I would not attempt to be accurate on the formula.

My memory is that these deviations, each individual difference taken and squared; this divided by the number of determinations, minus 1; that is, if there were five replicates, and the square root of this quotient taken,—I would not wish to be taken that that is an absolute—

Q. Did you utilize that in applying changes on 475 your chart, Defendant's Exhibit 8?

A. I utilized only the figures that he gave for said standard deviation.

Q. And am I right that th columns that appear on this sheet represent differences based on adding to or subtracting from the average, the standard deviations?

A. That is correct.

Q. Is it your understanding that the standard deviation of the mean is the average difference of the replicates from the mean?

A. No, it is not.

Q. Did you use that in this chart, Defendant's Exhibit 8?

A. That standard deviation— In other words, when you have a mean of five determinations, the most favorable interpretation of that that you could have to give the least standard deviation, would be where two of the determinations were above the mean by exactly the standard deviation and two of them were below the mean by exactly the standard deviation. That is the representation in that chart.

Q. Do you consider that that is an accurate method of comparing such data to apply the standard deviation of the mean? Is that your position?

A. It is the best that could be done from the data 476 at hand.

Q. Now, when there is no significant difference between two means, is it statistically correct to assume that this difference is a real difference instead of just an apparent one?

A. No; it is not correct.

Q. On what basis, then, could you transfer an insignificant difference between two means from one series of columns to another series of columns, as you have done in the chart, Defendant's Exhibit 8, as represented by the green portions?

A. Because they had been included in the comparison in between 4 and 5; they are there.

Q. Now, do you consider the green portion at the top of column 1 under Number 3: Selected Strain, a significant difference as compared with the first red column under Number 2: Non-Selected Strains?

A. No; the difference in average; statistically, was not a significant difference.

Q. Now, I am correct, am I not, in stating that the Series Number 3 and 5 on your Exhibit 8 represent concurrent tests using particular strains of clover, Series 3 alone, and Series 5, mixed; that is correct, isn't it?

477 A. They were so presented.

Q. And that is the way you presented them here?

A. Yes.

Q. And isn't it true that the nitrogen yield obtained in Series 3 and Series 5 is entirely independent of the clover strain used in Series 2?

A. Yes.

Q. Then what possible justification is there in your subtraction of the green portion, the difference between the average in 2 and 3, from the columns, Series 3 and 5?

A. Because the indication there, those two strains,—if you want to make a comparison such as has been done there it isn't fair to start out with strains which show that much difference, statistically significant or not, in order to reach a conclusion over there.

Q. Of what difference,—how much difference? Do you mean this difference in column 1?

A. Yes.

Q. Didn't you just tell me that that wasn't significant?

A. It is not statistically significant and yet it is a difference, in presenting it to interpret this result.

Q. Supposing you had a difference in that strain which went halfway down or, say, three fourths of the way

478 down on column 2, Series 3, and you applied that to Number 5, you would practically be feeding nitrogen into the air; you wouldn't have anything left here, would you?

A. That could be possible.

Q. That is on the basis of your calculation, that could be possible, is that correct?

A. Yes.

Q. I want to ask you this again now: You understand, of course, that the tests, Series 3 and 5 of the patent, are tests entirely separate and distinct from the tests of Series 2?

A. They are being compared with Series 2.

Q. But will you answer my question?

A. They were run separately, yes.

Q. They are distinct and separate tests, are they not?

A. Yes.

Q. Now, when was this LEGUME-AID made by the defendant company ready for distribution by the defendant company?

A. There was one lot made in December, 1940 and distributed in January and February, 1941.

Q. And if I understand it correctly, that distribution was sent out as a field test, is that correct?

A. That was sold; not sent out as a field test.

479 Q. Didn't you send it out to get a field test?

A. We sent it out into one state; all of the alfalfa and clover culture that went into one state that year was this lot of culture.

Q. And was that sent there for a field test?

A. It was sent there to get field results.

Q. And then subsequently you did announce that this LEGUME-AID was for sale to the trade, did you not?

A. Yes, we did.

Q. And that was after this field test and when was the date that you made this announcement?

A. The announcement was made before we had any results of the field test at the Seed Trade Convention, at St. Louis, in the latter part of June, 1941.

Q. Now, referring again to Defendant's Exhibits 5 and 7, were any of the strains reported on in these tests, strains that are used in the commercial culture of the defendant, of LEGUME-AID?

A. The strains used in LEGUME-AID are all included in this test.

Q. Can you point out which ones they are?

A. No; I can't point out which ones have been used in that lot or in a particular lot.

480 Q. You don't know which of the strains which are contained on Defendant's Exhibits 5 and 7 are strains that are used in the commercial article?

A. Yes, but not in any particular lot.

Q. What do you mean by any particular lot?

A. For example: That package—I can't tell that strain. 2A2 is contained in that package.

Q. How often do you change your strains?

A. As I said, I may change them— They are revised and if I find of the ones I have been using one of them has deteriorated it may not be thrown away from the collection but it isn't used in the test after that time.

Q. Do you change these strains as often as once a year?

A. That is about the frequency that I am able to run greenhouse tests.

Q. These tests which were made in 1944? Can you give me the strains in your commercial article that you used in the year 1944?

A. I can give you some of them. 2A5 was used; 202 was used; 2A3 was also used.

Q. And that is all you remember, at the present time?

A. That would be probably the ones that were used following this test.

481 Q. And how many of these strains that are shown on these two exhibits, Defendant's Exhibits 7 and 5, are old strains that have been used by your company for a long time?

A. Well, 201 has been in our possession for a number of years; 2A2—

Q. When you say a number of years,—can you make that a little more specific?

A. Some of these I obtained as early as November, 1934.

Q. Can you tell me which ones of those they were?

A. No; not with certainty, I can't. Some of them were received; some of these I just kept through after 1937; I think one of these may have been obtained in 1940 or 1941.

These dates are the dates at which they were put into a pure culture collection and have been a matter of record since that time.

Q. And some of those strains may have been obtained within the last year or so?

A. No, none of these.

Q. None of those?

A. The latest here are 1941.

Q. And do you know how many of those strains would be within the year—

482 You gave me the isolated year here.

A. That means the isolated year here, yes.

Q. Does that mean the year you got it?

A. If it was my own testimony, yes, it refers to the original year the culture was made; that indicates how long that it has been in existence as a pure culture.

Q. Since that time?

A. Since that time.

Q. Are the strains of Defendant's Exhibit 7 the same as of Defendant's Exhibit 5?

A. They are.

Q. Now, I would like to ask you, Mr. Curie, when you have used in your testimony nitrogen fixation tests you mean tests for dry weight or tests in which the nitrogen content of plants is determined by a chemical analysis.

A. I mean tests of dry weight except as this one series of nitrogen analyses are presented here.

Q. In other words, this one that you say represented here is shown on what exhibit where you use chemical analysis?

A. On Exhibit 5 the final two columns refer to nitrogen.

Q. And you made no other chemical analysis except that one.

A. That is all I have made on these cultures.

483 Q. That is the only one you have ever made?

A. On these cultures, yes.

Q. Now, had you ever evaluated the effectiveness of your commercial mixed cultures on the basis of the dry weight determination prior to 1944?

A. I think such tests were made. I did not run them myself.

Q. You don't know of any, personally?

A. No; not of personal experience.

Q. And you were in charge there so you would almost think you would know, wouldn't you, if the tests were run?

A. I have stated I was not in charge at the time I went to Agricultural Laboratories.

Q. You mean before you got your present position you think such tests may have been made?

A. A test run on the mixed culture?

Q. Yes, on a mixed culture?

A. I don't know. No—

Q. No tests were made of that type prior to 1944?

A. No.

485 LEWIS W. ERDMAN, called as a witness herein on behalf of the defendant, being first duly sworn, was examined, and testified as follows:

Direct Examination by Mr. Staley.

Q. Will you please state your name, your age, and your present occupation?

The Witness: A. Lewis W. Erdman; age 49; present occupation, Director of Research and Production for The Nitragin Company, Milwaukee, Wisconsin.

Mr. Staley: Q. Would you please state your education and your general experience in this field of plant pathology and bacteriology?

A. I received my Bachelor of Science Degree in the Maryland State College of Agriculture, in 1916.

For two years, from 1918 to 1920, I was on the staff of the Maryland Experiment Station, and in the next three years I was on a Research Fellowship at the Iowa Agricultural Experiment Station.

At the Iowa State College, I received my M.S. De-
486 gree in 1921, and in 1922 Ph.D Degree. The year after graduation from Iowa State College, I was on the National Research Council Fellowship at the Washington State College, and from 1923 to 1927 I was Assistant Professor of Soils and Assistant Chief in Soil Bacteriology at the Iowa Experiment Station and College.

1927 to 1928 I was Professor of Soil Technology at the University of Maryland, and since 1928, in November, I have been in my present position.

Q. You have been Director of Research at The Nitragin Company since 1928?

A. That is right.

Q. Dr. Erdman, as Director of Research of The Nitragin Company do you come in contact with any of the advertising literature of The Nitragin Company?

A. Yes, since I have been with the company, I have a very close contact with it and O.K. it and usually supervise the production of it.

Q. Could you recognize an advertisement of The Nitragin Company, if it was put in your possession?

A. I could.

487 Mr. Staley: Q. I hand you herewith an advertisement entitled "NITRAGIN FACTS THAT BEAR

GREAT WEIGHT", and ask you if you can identify that as an advertisement of The Nitragin Company?

A. This is a catalog of Nitragin prices, dated 1923. It gives miscellaneous cuts, price cuts and other information. Although it was put out before my coming to the company, I recognize the registered trade name, the can and other advertising material which we are using at the present time in many of our advertisements.

Mr. Staley: If Your Honor please, I would like to identify, if opposing counsel agree however, a photostatic copy of the advertisement that has just been identified by the witness. As Defendant's Exhibit Number 10.

(Said photostatic copy of advertisement headed "NITRAGIN FACTS THAT BEAR GREAT WEIGHT", dated 1923, showing prices of The Nitragin Company, Inc., of Milwaukee, Wisconsin, and
488 giving miscellaneous cuts, price cuts and other information, was thereupon marked as Defendant's Exhibit Number 10 for identification.)

Mr. Staley: Q. Dr. Erdman, would you look at that advertisement and tell us if there is any item of product, or any product on there indicated as a mixed culture as it has been identified in the course of this trial?

A. Yes. On the inside page, near the bottom, is noted Garden Size Inoculation three-in-one for peas, sweet peas and beans.

The Witness: Also in the center of the page is a cut, advertising garden Nitragin for peas and beans. At the bottom of the large ad, on the inside page, garden packages listed for peas, beans, sweet peas, and the same is true on the opposite side of the page.

Mr. Staley: Q. These items or these references that you have made are to a mixed culture for peas, sweet peas and beans as identified on the exhibit, is that correct?

A. That is correct.

489 Q. Has this product been manufactured by The Nitragin Company since the time you went with The Nitragin Company in 1928?

A. Yes. It has, but since this price list was published, we have included several other strains belonging to different cross-inoculation groups.

Q. Have you ever tested the garden mixture as it is referred to here in the advertisement?

A. Yes. In our routine tests, we have made tests of samples of garden size Nitragin on all of the legumes, for which it is intended.

Q. Have you made tests on the individual strains of the cross-inoculation groups that are included in this garden size inoculant?

A. Yes. All of these strains are tested before we use them in our commercial production.

Q. You make mention of tests. Will you tell us what kind of a test you apply to the single strains of bacteria, to determine their efficiency?

490 Mr. Staley: Q. (Continuing:) Will you please add to that question, whether you tested these single strains of the cross-inoculation groups prior to August 24, 1938, that is the filing date of the Bond Patent?

A. Yes, we have tested them prior to that date. We have since tested them, since that date.

Q. More than two years prior to that patent—

A. Oh, yes.

Q. —the filing date of that patent which was referred to now?

A. Yes.

Q. Will you please let us know the variety or type of test that you applied to these single strains of bacteria prior to the filing date of the Bond Patent or two years prior to that date?

A. Those tests are vegetative tests.

491 The Witness: Vegetative tests, using the legume: for instance, on peas, we will test these strains of pea bacteria with the idea of making a selection to get the more effective strains. In the majority of cases, this test need not go much further than just a vegetative test, which indicates, growing the plants in a sterile sand to which a nutrient solution has been added, everything except nitrogen. That is, we usually always will run a control in an uninoculated batch of seeds for comparison. For most practical purposes, we can get, by running a bunch of strains along at the same time, very brief comparisons from which we are able to make a selection.

Mr. Staley: Q. Would you say as a scientist, as one experienced in this field of plant bacteriology, that the vegetative tests are indicative of the percentage of nitrogen that is fixed in a plant?

A. It is an indication, yes. It doesn't tell you how much, but it is an indication.

Q. Did you ever, prior to the Bond Patent, or two years prior to that date of August 24, 1938, make any actual nitrogen determination tests, or run any nitrogen determination tests on the single strains of bacteria
492 that you had in the garden mixture?

A. Well, I am pretty sure that we had some tests along about 1935, '36, when we set up our nitrogen determination apparatus, but I wouldn't have those tests available.

Q. But you did make nitrogen determination tests prior to 1938?

A. Oh, yes; we have done that.

Q. On the individual strains—

A. On the individual strains.

Q. —of the bacteria that went into the garden mixed cultures?

A. Yes.

Q. Did you ever make any comparison tests between the individual strains of the bacteria that were in the mixed garden culture and the individual strains?

A. Not running at the same time, no.

493 Mr. Staley: Q. What strains were used, what strains of bacteria were used in the mixed garden culture, with reference to the stock of cultures that you had of these same varieties?

I am asking the witness what type of strains of bacteria went into the mixed garden culture with reference to the stock cultures of the various strains of, such as peas, beans, that they had in their stock culture?

A. In preparing our garden culture, we will use the same material for our regular production of pea culture, for instance, that is used by the canners or the seed pea growers; the same selection of strains that goes to make up that also goes into the production of our garden culture. The same is true for our bean culture. The same is true for our lima bean culture and lupine culture. All of these are included in our garden mixture.

Q. Doctor Erdman, I hand you herewith a sample of a product and ask you if you can identify it?

A. This is a package, can, garden size Nitragin for garden peas, garden beans, sweet peas and lupines, marked "Good until December 31, 1935."

494 Q. I also hand you herewith a set of photographs and ask you if you can identify those photographs, with reference to the sample that you have identified?

A. This looks like an exact photograph, on the top label.

Mr. Staley: If Your Honor please, I would like to submit the photographs that have just been identified by the witness, as being photographs of the sample, and have the photographs identified as Defendant's Exhibits.

I will introduce the photographs identified as Defendant's Exhibits 11-A, 11-B, 11-C and 11-D.

(Said photographs were thereupon marked as Defendant's Exhibits 11-A, 11-B, 11-C and 11-D, for identification.)

Q. Dr. Erdman, would you say when the sample of the can that you identified was produced?

A. This can of inoculant could have been produced any time between December 1st, 1934 up to and through October 31st, 1935.

Q. How do you establish that date?

A. Knowing the expiration date and knowing the time that we start to produce and cease producing culture for this given year.

495 Q. That is the same information as on the can, is it not?

A. Yes. That is the same information on the top cover.

Mr. Staley: I would like to have the can, which has been identified by the witness previously, presented for identification as Defendant's Exhibit No. 12.

The Court: All right.

(Said can labeled "NITRAGIN" of The Nitragin Company, Inc., Milwaukee, Wis., was thereupon marked Defendant's Exhibit No. 12 for identification.)

Mr. Staley: Q. Dr. Erdman, did you run any tests on nitrogen fixation with reference to the question of determining whether or not one strain of bacteria was inhibited with another, when it was put into association with the other strain?

A. Yes, I made such a test last Fall.

Q. Did you make a report of that test?

A. It hasn't been reported yet, no.

Q. Did you make any report at all?

A. You mean to a scientific publication or something?

Q. No, not to a scientific publication, but did you collect the data and compile it into a report?

496 A. Oh yes, I have such a report on those results.

Q. I hand you herewith a report and ask you to identify that.

A. This is a report of an experiment which I set up last Fall, to answer the question, if possible:

"Does one species of legume bacteria produce an inhibitory effect on another species within the same culture?"

This is the report prepared by me.

Mr. Staley: If Your Honor please, I would like to submit the report and have it identified as Defendant's Exhibit Number 13.

(Said report of Lewis W. Erdman headed "DOES ONE SPECIES OF LEGUME BACTERIA PRODUCE AN INHIBITORY EFFECT ON ANOTHER SPECIES WITHIN THE SAME CULTURE?" was thereupon marked as Defendant's Exhibit Number 13 for identification.)

497 Mr. Staley: Q. Dr. Erdman, will you please tell us the manner in which you set up your laboratory test and the procedure that you follow in obtaining the results that are presented on this report?

A. In this report, a selection was made of five pure culture strains of alfalfa bacteria and five pure culture strains of red clover bacteria. The dates under which these cultures were obtained are noted in the report, one of the alfalfa strains being as old as 1912 and one as recent as 1932. In the case of the red clover strains, the oldest strain was isolated, a red clover nodule in Minnesota, in 1932, three other strains were isolated in 1934 and the fifth strain was in 1935.

In order to prepare the cultures for this study, a pure culture of each single strain was inoculated into 250 c.c. of yeast-mannitol liquid No. 79 on September 1, 1944. One week later, single strain humus cultures were prepared by mixing 40 c.c. of each liquid suspension of bacteria with 50 grams 200 mesh dried and partially sterilized humus plus the addition of 12.5 grams of finely ground limestone to neutralize the acidity.

Mixed cultures were prepared by mixing 20 c.c. of a single strain alfalfa liquid suspension plus 20 c.c. of
498 a composite liquid suspension of red clover bacteria with 50 grams of humus and 12.5 grams of limestone.

This composite liquid suspension of red clover bacteria was prepared by mixing together 50 c.c. of liquid from each of the five pure culture suspensions of red clover bacteria, making a total of 250 c.c. of this composite liquid.

The culture treatments used in this experiment were as follows:

No. 1 Single strain alfalfa No. 3DOa1.

Should I go to the trouble of reading all these?

499 Q. I would like you to identify the strains and the general results that were obtained by the effect of those strains on the plants.

A. Well, as I have mentioned, these strains were selected from different original sources and, according to the treatments, alfalfa was planted in one-half gallon pots, earthenware glazed pots, which were prepared as shown in Figure 1.

Q. Now, with reference to Figure 1, what do you have reference to in that statement?

A. Figure 1 on Page 2 of this report. A layer of coarse gravel was first added, the watering tube put in place, washed bank sand was added next and the sand was thoroughly moistened with Bryan's modified Crone's solution. Each pot was covered with wrapping paper tied and sterilized in the autoclave for five hours at 15 pounds pressure.

The alfalfa seeds were first freed of legume bacteria and a sufficient number inoculated with each culture treatment to plant five pots. Planting of the alfalfa was done on September 25. After planting a thin layer of fine gravel was put on top of the sand in each jar to reduce chances for contamination. Extreme care was exercised in watering; sterilized distilled water was added when needed and at 30-day intervals more sterilized Crone's solution was added.

500 The plants were photographed on January 9, 1945, and harvested on January 18, 1945. The roots were washed free of sand and the whole plants from each pot were dried, weighed, ground, and samples analyzed for total nitrogen by the standard Kjedahl method for total nitrogen determination.

I have attached, going with this report, a complete set of pictures which were obtained in the experiment.

Q. Doctor Erdman, I hand you herewith a set of pic-

tures and ask if you can identify them as the pictures you have just referred to. (Handing photographs to witness.)

A. These are the six pictures obtained in this experiment. They are the pictures.

Mr. Staley: If the Court please, I would like to have these photographs identified as Defendant's Exhibits 14 A to F, inclusive.

The Court: All right.

(Which photographs portraying above described experiment were marked, respectively, for identification, Defendant's Exhibits 14 A to 14 F, both inclusive.)

Mr. Staley: Q. Now, Doctor Erdman, will you please explain the general results of your tests, using the pictures and the data you have at hand?

501 A. Each picture is made from five pots inoculated with a single strain of alfalfa bacteria and below this, this same strain of bacteria plus a mixture of the five strains of red clover bacteria prepared in accordance to the article.

At the top of each picture is a set of controls of five pots and these controls are the same for all of the pictures.

The first picture represents alfalfa bacteria strain 3DOa1. The second picture is from the—

Q. Would you identify those by exhibit numbers, Doctor?

A. By number?

Q. Yes, by exhibit numbers.

A. Yes, I have those here. The first is Exhibit A. The second picture Exhibit B. From strain 3DOa7. I might add 3DOa1, there seems to be no apparent difference. I might also add in each one of these pots there are twenty plants. 3DOa1, the differences are not very marked. One might say a rather uniform set of pictures.

The Court: I don't understand what you mean by "control".

The Witness: The control is the series of pots to which no legume bacteria were added; that is the uninoculated pots. These plants were forced to get all of their nitrogen from the seed of the alfalfa plant. When that was associated—

502 The Court: Not inoculated.

The Witness: Not inoculated may have been a better term.

In the case of 3DOa7, there is an apparent stimulation where the clover bacteria were added in mixed culture with the alfalfa strain 3DOa7.

Exhibit C, Strain 3DOa10, no noticeable differences between the single strain and the mixture.

Exhibit D, Alfalfa Strain 3DOa12, very similar results, hardly any differences.

Exhibit E, one can notice no apparent differences.

Exhibit F, there is an apparent stimulation, possibly due to the mixture. It is due apparently to the mixture.

In order to make the study more complete, as I stated, the plants were harvested, dried and ground and subjected to nitrogen analyses.

504 Mr. Staley: Q. Doctor Erdman, what is your opinion with reference to the question of inhibition of one plant bacteriological specie when put in association with another?

A. I do not believe there is such inhibition among the legume bacteria, the different species.

Q. Upon what do you base your opinion?

A. I base that opinion upon very, or, practically no literature bearing directly on this particular subject except possibly this Bond patent.

Q. You agree with this statement in the Bond patent, as quoted from Page 2, Column 1, Line 74?

> " —it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented."

A. I do not agree with that statement.

The Court: Did you have any opinion about that in 1938?

The Witness: If I was asked that question in 1938, I think I would have made the same statement.

505 Mr. Staley: Q. Doctor Erdman, what is your opinion with reference to a question of whether the various strains of legume bacteria remain constant in their effect upon the legumes over a period of years?

The Witness: A. It is well known that a strain of legume bacteria will maintain its efficiency over a period of years but to say that that strain will be constant and fix constant amounts of nitrogen when subjected to a given plant, is not true. In other words, they will vary from time to time.

Mr. Staley: Q. Have you ever run any test to determine that, whether or not they do vary from time to time?

A. Yes, we have in our laboratory run tests different years using the same strains on the same legumes.

Q. I hand you herewith copies of tests and ask if these are the tests you have been referring to. (Handing documents to witness.)

A. These are the tests that I had in mind from our laboratory.

The Court: And tests show that the strains do not remain constant?

The Witness: That is right.

506 The Court: And vary from time to time?

The Witness: Vary from time to time, different growing—

The Court: Doesn't that agree with both of the other experts?

Mr. Staley: Well, Mr. Bond has made a statement in his direct testimony that the strains remain constant and we are of the opinion—

The Court: Well, he didn't— As I remember, he said some of them had remained constant as long as twenty years but he didn't make a statement, as I remember it, that positively all of them remained constant for a long period of time.

Mr. Staley: Well, the inference was made that once a strain was obtained, that was their so-called alpha strain, that the efficiency of that strain remained relatively unchanged from time to time and, as he said, as long as twenty years.

Doctor Erdman has performed these tests over a period of years from time to time and we would like to submit this evidence on that basis.

The Court: All right. I may not have an accurate recollection of what Mr. Bond said.

Mr. Staley: If your Honor please, I would like to submit photostatic copies of the sheets of tests that have been identified by the witness and identify them as

507 Defendant's Exhibits 15-A to D, inclusive.

Mr. Staley: Q. Doctor Erdman, you have studied the Bond patent 2,200,532, have you not?

A. Yes, I have.

Q. Have you made any analysis and examination

508 of the tests and other data that is disclosed in the Bond patent 2,200,532?

A. I have studied it, yes.

Q. From these data, what is your opinion as to whether they establish a doctrine or precept of inhibition as a result of the mixing of the different species of the Rhizobium in a composite culture?

A. I do not think they establish that teaching, that doctrine.

Q. Why?

A. For one thing, I feel that there should be a much —in order to establish a point like that, there should be a much larger number of strains tested than he has given here.

Mr. Staley: That will be all, your Honor.

509 *Cross-examination by Mr. Thiess.*

Q. Dr. Erdman, as I understand, you have been with the Nitragin Company since 1928?

A. That is right.

Q. And was that the first contact you had in the production of cultures of this kind, commercially, for inoculation?

A. Commercially, yes.

Q. Prior to that time your work was more or less of an instructor and on fellowships doing—

A. Research work.

Q. —research work?

A. Yes.

Q. Now, you referred to this garden culture put out by the Nitragin Company. How do you pronounce that?

A. Nitragin.

Q. And I understood that you said that originally you put this culture on the market, that is, it was put on the market according to the can in the photographs that we have, for garden peas, garden beans, sweet peas, and 510 lupines. That is correct, is it?

A. That is correct.

Q. And thereafter, as I understand your testimony, you added to the strains?

A. Just one other strain.

Q. What other strain did you add?

A. The soy bean.

Q. And when did you add this other strain, the soy bean strain?

A. Oh, I believe just two years ago.
Q. That would be in 1943?
A. I think that is approximately correct.
Q. And did you say that you made tests on the individual strains of these cultures that are in this garden culture?
A. Yes, I did.
Q. And when you said you made tests on the individual strains, were those the strains that your company were using for single cultures?
A. That is right.
Q. And your company does put out single cultures for field work?
A. Yes, sir.
511 Q. And do you recommend these single cultures for field work?
A. We do.
Q. And do you recommend your garden culture for field work?
A. No.
Q. Why not?
A. Because it isn't sufficient to go over enough seeds to put on a field basis.
Q. Well, if you made the can large enough and put all these together, have you ever made any investigation to determine whether that would be satisfactory for field work?
A. It would be satisfactory for field work if there was a demand for it, yes.
Q. Well, I asked you, did you make any investigations or tests to determine whether it would?
A. No, I have not.
Q. Now, you referred to these tests that were applied to these single strains, and, as I understood, you referred to them as a vegetative test.
A. Vegetative, yes.
Q. By vegetative test you mean merely looking at
512 them?
A. I mean inoculating the strain on the legume and watching it grow.
Q. And you make your determination from merely looking at it?
A. Looking at it and examining it for nodules, yes.
Q. Now, as a man skilled in this art, would you wish to represent to this Court that that is a scientific way of

determining whether you are getting good nitrogen fixation in a plant?

A. No, I would not say so.

Q. Do you agree that in order to get good scientific results you would have to make a nitrogen chemical result?

A. Yes.

Q. I mean test, I should have said.

A. Yes.

Q. Now, referring to this can marked for identification as Exhibit 12. Where did that come from?

A. That came from our laboratory.

Q. From your laboratory?

A. Originally.

Q. Well, I mean when?

513 A. When?

Q. Did you produce this?

A. It was produced under my supervision when I was there during that year, yes.

Q. Well, what I have in mind, this particular can, did you get that out of the files or from the shelves of your company when you were asked to take part in this litigation?

A. No, sir.

Q. Well, where did it come from at that time?

A. I do not know.

Q. You don't know where this can came from?

A. No, sir.

Q. So under those circumstances you don't know where this can has been. How about the date on this can, where is that?

A. It is on the top label.

Q. On the top label. And that date, you say, was put on there when the can was put out?

A. That date is lithographed on the cover when we order our containers, and when we make the culture for that year it naturally is put on.

Q. So from that you conclude that this culture 514 was made prior to the date on the can?

A. Why, yes, prior to the date on the can.

Q. Now, who did you consult with when you were first brought into this litigation to make these tests, et cetera?

A. Mr. Elmers, of Agricultural Laboratories.

Q. Anybody else?

A. Yes, my superior of the company, Mr. L. D. Matchette.

Q. And who did you consult with as to the manner and type of tests that you were going to make?

A. That was discussed with Mr. Elmers.

Q. And did Mr. Elmers tell you to make tests merely on the alfalfa strains?

A. No.

Q. Your tests were made exclusively on the alfalfa strains to see whether there was inhibition on the alfalfa strains?

A. I made a test also on red clover.

Q. Have you produced that test here?

A. No, I have not.

Q. How many tests did you make on red clover?

A. I had almost an identical experiment set up on
515 red clover as reported for alfalfa.

Q. And did you run that test?

A. That test was run and completed, but unfortunately we had a little trouble with mildew on the strain of red clover that we used and a number of the plants were destroyed during the growing period. We did not, therefore, have a constant uniform stand in the pots and I concluded that the results would probably not be reliable on that count.

Q. So you did not follow the test through?

A. The test was followed through but I do not wish to lay any emphasis on the data.

Q. Now, these tests that were made that have been produced, that show the results that you got on the alfalfa, were made for this litigation?

A. Yes, they were made for this litigation.

Q. You knew that this litigation had been started and that these tests were going to be used in this litigation?

A. That is right.

Q. And you were cognizant long before that, were you
not, that Mr. Bond had contended that there was
516 inhibition and that it was the fact that he found non-
inhibitive strains, that that fact made it possible to make a mixed culture, were you not?

A. I was familiar with his patent when it came out, and of course that was in it, yes.

Q. Well, you were familiar also, were you not, or you knew of the fact that Mr. Bond had read a paper before a group at San Francisco, stating what he had discovered and invented and telling about this inhibition?

A. The report of that work doesn't bring out—I knew he gave a paper.

Q. That is all I am asking. You knew he gave that paper?

A. Yes.

Q. You had a representative there at that meeting, did you not?

A. Yes, we did.

Q. And you have never made any statement, either in the press or in the scientific journals of any kind, in which you denied that what Mr. Bond stated there was not correct, have you?

A. No.

517 Q. Now, on these photographs that you have presented I notice that—oh, you have a copy of them there?

A. Yes.

Q. —that the plants in the various series of pots are substantially uniform and there is no very wide deviation between the pots?

A. That is right.

Q. That is correct, is it not?

A. Yes.

Q. Now, you are, of course, conversant with the pictures of the tests that were run on clover by Mr. Curie, are you?

A. Yes, I am familiar with those.

Q. You have noticed the deviation in the growth of the various plants in those photographs?

A. Yes, sir.

Q. And do you, as an expert in the art, believe that where you have a deviation of the type that you have got there, that those tests run in that manner are scientifically properly conducted tests?

A. The fact that they are not uniform doesn't
518 disqualify them on the basis of a scientific test.

Q. Well, I mean, some of these photographs where you have this—for instance, one of the photographs that I referred to this morning. This photograph, for instance, it is Defendant's Exhibit 6-G, where you have a rather substantial growth in pot No. 4 in the upper series, and substantially the same growth in the pots in the lower series.

A. Yes.

Q. Now, if the growth in the pot No. 4 in the upper series was due to the introduction of nutrients from the outside, isn't it also possible that that was the very thing that caused that growth in the pots below?

A. Well, I would not say that that would be necessarily true.

Q. But it could be true, could it not?

A. It would be possible but not necessarily.

Q. Now, in conducting a test of this character, 519 would you consider it a good test in which you had control plants and you threw the control plants away at the end of the test?

A. Well, it all would depend on what you want to show from the test.

Q. Well, if you wanted to show the very thing that you wanted to show in your alfalfa tests, whether there was inhibition or not.

A. I can produce the data from my—

Q. Now, will you answer my question?

A. Would you repeat it?

Q. Would you consider it a good test if you threw away the control pots?

A. Ordinarily, no, it would not be.

Q. All right. Now, can you tell me how long the different strains used in your tests, bacteria strains, had been associated together in the mixed culture at the time the culture was applied to the seed?

A. Are you referring to this experiment?

Q. The experiment you made, yes.

A. Nineteen days.

Q. Nineteen days?

520 A. In the humus, in association with the strains from the different groups.

Q. The two—

A. The alfalfa and clover.

Q. —had been together in the humus for nineteen days, is that correct?

A. I think it is nineteen days. Seventeen days, to be exact.

Q. Now, what method of statistic analysis did you employ in your tests reported in Defendant's Exhibit 13?

A. I applied an analysis of variance.

Q. And an analysis of variance is one of the real accepted tests for that purpose, is it not?

A. It is.

Q. Now, with respect to this consistency of strains, the characteristics of the strains, you will agree, will you not, that there are strains that have been consistently 521 used for twenty to possibly even thirty years, is that correct?

A. That is right.

Q. And if these strains varied widely there would not be much object in making these cultures, would there, because you would never know what you would get?

A. You have to continually be testing them all the time.

Q. You have to test them all the time?

A. Yes.

Q. What do you mean by that? Will you tell me how often?

A. Well, we will test as many as we can each year, every year.

Q. All right, you test them every year and you find that most of them carry through and keep constant characteristics, do you not?

A. That is true, but they don't always—the first high strain one year will not necessarily be a high strain the next year.

Q. There may be some exceptions, but as a rule they run pretty much alike, do they not, the good strains?

522 A. The good strains will maintain themselves pretty well over a period of years.

Q. And in this art the manufacturers of these cultures do use good strains, do they not?

A. I hope they do, yes, sir.

Q. And if these strains did not maintain these constant characteristics, you would have to test them oftener than once each year, would you not?

A. Well, I would not say any more often than once a year, no, that ought to be sufficient.

Q. Well, that would indicate that you are pretty well satisfied that the strain holds its own for a year's time or you would test them oftener, would you not?

A. That is true, and another reason for testing is the fact that they may become contaminated during the carrying them over in the laboratory.

Q. I appreciate that that is another reason that you test them.

A. Sure, to make sure that we have pure cultures to deal with at all times.

Q. In other words, you always have that problem,

523 they have got to be kept—

A. Pure.

Q. —pure, and there is a possibility that something in the air might contaminate them?

A. That is right.

Q. Now, had you prior to August, 1938, made any search of the scientific literature to determine what information was given as to the effect that mixing different species of Rhizobium would have on the nitrogen fixing ability of every species?

A. No, I did not.

Q. You have never made any such investigation, have you?

A. I haven't been particularly interested in the problem.

The Court: Q. Does your company produce a combination?

A. Just the garden size.

Q. I meant for clover and alfalfa?

A. No, sir.

Q. Just the garden.

524 A. Yes, sir.

Mr. Thiess: Q. Now, did you prior to August, 1938, conduct any efficiency tests to determine the nitrogen fixing ability of any species of Rhizobium on its host plant when mixed with other species, as compared to the nitrogen fixing ability of the same species when used alone on its host plant?

A. No.

Q. Then when you stated that in 1938 you did not believe that there was anything in the literature to show that there might be inhibition, what did you base that opinion on?

A. Didn't you ask me if I made tests?

Q. Prior to 1938. That was my previous question and you said no.

A. I don't see the relation to your second question.

Q. Well, you told the Court that you would give that opinion as of 1938, do you remember that?

A. Yes.

Q. Well, now, if you had not made any tests and you had not made any search of the literature, on what did you base that opinion?

525 A. Well, I would base it personally on the fact that we have been putting up this mixed culture for garden size for a period of years, with very fine results.

Q. But, as I understand it, that garden culture was used merely for garden purposes. You sold the single culture for field purposes, that is correct, isn't it?

A. That is right, yes.

Q. And does your company—

The Court: The statement, I think, that the Doctor answered me on was this one contained on page 2, in the first column, beginning with line 74 of the patent, where it says:

> "It was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented."

Now he says he didn't agree with that.

Mr. Thiess: That is right.

526 The Court: And his answer would be the same in 1938. He did not agree with the statement that it was generally believed or generally accepted in the profession, is what I understand his statement to be.

Mr. Thiess: Yes.

The Court: Now, am I to understand that that is merely your opinion as to the question, rather than an opinion as to what the persons familiar with the art believe about it?

The Witness: Well, I would say it is my own opinion and persons familiar with the art also.

The Court: But I thought I understood you to answer the question a few minutes ago that you had not investigated the literature on the art at that time.

Mr. Thiess: That is correct.

The Witness: Well, if I made that statement I would like to withdraw it, because I have investigated the literature. In fact, I have read this book from beginning to end.

Mr. Thiess: Q. What book are you referring to?

527 A. This Root Nodule Bacteria and Leguminous Plants, by Fred, Baldwin, and McCoy; as well as many other pieces of literature.

The Court: Well, I expect I must have misunderstood you then, because you would hardly have made the statement I thought you made. I misunderstood you.

Mr. Thiess: You did not misunderstand him.

The Witness: I misunderstood the question if I answered that way.

The Court: I don't want to—

Mr. Thiess: Q. Now, you referred to this book. Do you understand that that book makes that sort of a statement?

A. That book?

Q. Yes.

A. In one instance it makes a statement that they are not antagonistic.

528 Q. Where do you find that in the book? Is that the statement you are referring to (indicating in book)?

A. That is it.

Q. Did you ever read the Alicante article on which that statement is based?

A. No.

Q. (By Mr. Thiess) Now, have you any other articles?

A. That show what?

Q. That show that there is no inhibition?

A. I know of no articles that give definite proof of inhibition.

Q. But a while ago you said you read that book
529 and other articles. Now, have you got any article that gives proof that there is not inhibition?

A. That there is not inhibition?

Q. Yes.

A. I couldn't cite any right now.

Q. On this cover, Doctor, we find the name over the NITRAGIN, which is your trade name for the product: Nobbe-Hiltner Process.

A. Yes, sir.

Q. Is the Hiltner there referred to the Hiltner that Mr. Bond was referring to the other day?

A. I would have to check on that to make sure. I wouldn't know exactly.

Q. You don't know what this Nobbe-Hiltner process is?

A. I know what that process is. Way back in 1896 when it came on the market it was just a process for growing these organisms and distributing them to the trade in commercial channels.

Q. Do you know whether the man of that process is this L. Hiltner?

A. I wouldn't be able to state definitely unless I had the original reference to the Nobbe-Hiltner that put out this original culture. I couldn't state definitely.

530 Q. Now you say you are thoroughly familiar with the Bible?

A. I couldn't recite it verbatim.

Q. I appreciate that, but referring to this book on Root Nodule Bacteria in Leguminous Plants, pages 294 and 295, there are, I would say, at least 12 or 14 refer-

ences to this man Hiltner. Would you say that that is the same man?

A. I suspect it is the same man, especially now since I see he has some articles dated 1887. However, I still wouldn't be able to prove it.

Mr. Thiess: That is all, Doctor.

Redirect Examination by Mr. Staley.

Q. Doctor Erdman, the tests that were made by Mr. Curie, or the photographs that were submitted during the testimony, that were made by Mr. Curie and were referred to you in the cross-examination by counsel for the plaintiff, and I would like to ask your opinion
531 as to whether the tests which have been referred to here and have been considered during the testimony are sufficient to determine the question of whether inhibition or non-inhibition exist even if there were no control pots used?

A. I would say that the data would be sufficient without the controls.

The Court: You are speaking of the tests made by Mr. Curie?

The Witness: Yes, sir, to determine inhibition among these legume bacteria.

The Court: Were his tests any more extensive than those made by the patentee here, as disclosed in the patent?

The Witness: I would say so, yes, sir.

Re-cross Examination by Mr. Thiess.

Q. Would you say that that would be true, the answer that you just gave on redirect, if the control pots were badly contaminated?

A. If the control pots were badly contaminated it would be a question of what— When you have a contaminated control you cannot tell from where they came and it might be misleading to make that interpretation.

532 Mr. Thiess: That is all.

(Witness excused).

Mr. Greer: I think we might at this time take up the offer of all of the exhibits on behalf of the defendant from

1 to 15-A, B, C and D. That includes the series numbers 11-A to B, 14-A to S, and 15-A, B and C, all that have been marked for identification.

The Court: Is there any objection to any of those?

Mr. Thiess: Oh, yes, there are.

Mr. Neuman: If your Honor please, we reserve the right to object to Number 5, 6-A to L, and 7, because we have not completed our cross-examination of Mr. Curie.

The Court: All right.

535 The Court: Then the exhibits will be received in evidence from 1 to 15, inclusive, with the exception of 5, 6 and 7.

(The chart entitled: CULTURE CHART AND 1932 PRICE LIST was received in evidence as Defendant's Exhibit 1.)

(The package entitled "INOCULATION", "McQUEEN'S INOCULATOR", "GOOD FOR SWEET PEAS—LUPINES, GARDEN PEAS AND BEANS", was received in evidence as Defendant's Exhibit 2.)

(The photographs portraying the front and back side of package, Defendant's Exhibit 2, were received in evidence as Defendant's Exhibit 3.)

(The photostatic copy of sheet of advertisement and the photostatic copy of WHOLESALE PRICE LIST, effective July 16, 1937—Season 1937-38, of McQueen's Inc., Baltic, Ohio, in re McQueen's Seed Inoculants,
536 etc., were received in evidence as Defendant's Exhibit 4.)

(The document entitled: BOND PATENT No. 2,200,532: NITROGEN FIXED PER 10 PLANTS CLOVER, etc. was received in evidence as Defendant's Exhibit 8.)

(The carbon copy of letter dated June 30, 1941, addressed to Dr. H. W. Bachelor, Ohio Agriculture Experiment Station, Wooster, Ohio, from I. H. Curie, was received in evidence as Defendant's Exhibit No. 9.)

(The photostatic copy of advertisement headed "NITRAGIN FACTS THAT BEAR GREAT WEIGHT", dated 1923, showing prices of The Nitragin Company, Inc., of Milwaukee, Wisconsin, and giving miscellaneous cuts, price cuts and other information was received in evidence as Defendant's Exhibit 10.)

(The photographs of the can showing the words:
537 "NOBBE-HILTNER PROCESS, NITRAGIN FOR GARDEN PEAS; GARDEN BEANS; SWEET PEAS AND LUPINES, GOOD UNTIL

DECEMBER 31, 1935" (Defendant's Exhibit 11-A for identification); and showing the words: "THE ORIGINAL LEGUME INOCULATOR" "NITRAGIN", etc. (Defendant's Exhibit 11-B for identification); and showing the word DIRECTIONS (picture of side of can sample)—USE ONLY FOR SEEDS STATED ON TOP LABEL, etc. (Defendant's Exhibit 11-C for identification); and showing the word: "CAUTION", etc. and the word: "GUARANTEE", etc. (Defendant's Exhibit 11-D for identification) were received in evidence as Defendant's Exhibits 11-A to -D, inclusive.)

(The can labeled "NITRAGIN" of The Nitragin Company, Inc., Milwaukee, Wis. was received in evidence as Defendant's Exhibit 12.)

(The report of Lewis W. Erdman headed "DOES ONE
538 SPECIES OF LEGUME BACTERIA PRODUCE AN INHIBITORY EFFECT ON ANOTHER SPECIES WITHIN THE SAME CULTURE?" was received in evidence as Defendant's Exhibit 13.)

(The six photographs, each containing pictures of three rows of jars with five jars in each row, the top row entitled: "ALFALFA" and "CONTROLS"; the middle row of jars containing the label: ALFALFA BACTERIA STRAIN 3DOa1, ALFALFA BACTERIA STRAIN 3DOa7, ALFALFA BACTERIA STRAIN 3 DOa10, ALFALFA BACTERIA STRAIN 3 DOa12, ALFALFA BACTERIA STRAIN 3 DOa15 and 5 STRAINS ALFALFA BACTERIA, on the photographs labelled 14-A, -B, -C, -D, -E and -F, respectively; and the bottom row containing the label entitled ALFALFA BACTERIA STRAIN 3DOa1 PLUS 5 STRAINS RED CLOVER BACTERIA, on Exhibit 14-A and same title but with numbers 3DOa7, 3DOa10, 3DOa12, 3DOa15 on Exhibits 14-B, -C, -D, and -E respectively, and the bot-
539 tom row label on Defendant's Exhibit 14-F of 5 STRAINS ALFALFA BACTERIA PLUS 5 STRAINS RED CLOVER BACTERIA, was received in evidence as Defendant's Exhibit 14-A to 14-F, inclusive.)

(The photostatic copies of sheets of tests marked Defendant's Exhibit 15-A to 15-D, inclusive for identification and being each of two sheets, and entitled as follows: EXPERIMENT NO. 1—CRIMSON CLOVER, Sept. 22 to January 7, 1938 and CRIMSON Clover—Trifolium incarnatum, Oct. 19, 1939 to Jan. 20, 1940, being the two pages of Defendant's Exhibit. 15-A; entitled: RED CLOVER—Trifolium pratense, Oct. 18,

1939 to Jan. 15, 1940 and EXPERIMENT No. 1—RED CLOVER, Sept. 21 to Dec. 14, 1937, being the two pages of Defendant's Exhibit 15-B; and entitled: TABLE 3: NITROGEN FIXATION BY TWENTY STRAINS OF R. MELILOTI ON ALFALFA, BURR CLOVER AND SWEET CLOVER, Oct. 15 to Dec. 10, 1938, and TABLE 3 (continued) being the two pages of Defendant's Exhibit 15-C; and entitled: TABLE 5: NITROGEN FIXATION BY
540 TWENTY STRAINS OF R. MELILOTI ON ALFALFA BURR CLOVER AND FENUGREEK, Feb. 10 to April 17, 1939 and TABLE 5 (continued), being the two pages of Defendant's Exhibit 15-D, were received in evidence as Defendant's Exhibit 15-A to 15-D, inclusive.)

541 DR. THOMAS FRANKLIN MANNS a witness called on behalf of the defendant, being first duly sworn, was examined and testified as follows:

Direct Examination by Mr. Greer.

Q. Will you please state your full name, age, residence, and present occupation?

A. Thomas Franklin Manns; age 69; occupation, plant pathologist and soil bacteriologist, University of Delaware, Newark, Delaware.

Q. And where is your residence, Doctor?

A. Newark, Delaware.

Q. Will you please state just briefly to the court, Doctor, and don't be afraid to talk out loud,—I think everybody in this courtroom with the exception of myself, wants to whisper about something.

Mr. Thiess: I take exception to that.

Q. (Continued by Mr. Greer) Will you please state what your training, education and experience has been along this line of plant pathology and soil bacteriology?

A. I took my undergraduate work at North Dakota State College in 1896-1901; I took my Master's degree there in 1901 to 1903 in the field of soil microbiology,
542 diseases of flax carrying over in the soil.

I have been in the field of plant pathology and microbiology since 1907. Three years I was in the Philippines, from 1904 to 1907 as Provincial High School Superintendent in Science, teaching science and agriculture.

In 1907 I went as assistant to the Experiment Station, Wooster, Ohio, and was there as assistant botanist from 1907 to 1911.

In 1911 I was placed as head of the Department of Soil Bacteriology, which position I held for one year.

In 1912 to the present I have been head of the Department of Plant Pathology and Soil Bacteriology at the University of Delaware.

Q. Well, Doctor, can you tell us, in light of that experience throughout these years since your graduation from college, have you kept up or do you feel that you have kept up with the literature that has been published in this and other countries in connection with plant pathology and bacteriology, in connection with soils and leguminous plants, particularly?

A. I am teaching both sciences in the University and have research work in both sciences at the Experiment Station in Newark, Delaware. I feel that I have kept
543 very well up in the literature and science.

Q. Now, have you had any experience with letters patent of the United States, obtaining the same, and experience in connection with them?

A. I have taken out several patents.

Q. You acted as your own attorney in them, have you not?

A. I have, sir, yes.

Q. Now, have you made any particular study of the Bond patent in suit in this action, 2,200,532?

A. I have gone over the Bond patent very carefully.

Q. Well, I first want to invite your attention to the paragraph that was in discussion a few minutes ago, on page 2 of that patent. Have you got a copy of it before you?

A. I am afraid that I have left my copy down at my desk there and I will be very glad to get it or someone may bring it up, the one that has notes on it. There are two copies there.

Q. I want to invite your attention to the last two lines in the first column on page 2, with the understanding that the statement contained therein was made on August 24, 1938, and that statement reads that at that time
"it was generally believed that one species", that is,
544 a species of the genus Rhizobium bacteria "produced an inhibitory effect on another species within the same culture whereby symbiotic nitrogen fixation by

the plant and the organism was inhibited or even prevented".

Would you say that was an accurate or correct statement of the opinion that was held among scientists and those skilled in this art at that time?

A. I would say it is not.

Q. Well, have you, since then, Doctor, made any study at all in this art or read any articles or had referred to you any investigations that would lead you to believe differently now?

In other words, what is your opinion now as to whether or not there is this state of inhibition or lack of inhibition in this establishment of the so-called symbiotic relationship between Rhizobium bacteria and its host plant?

A. I have seen no evidence of it in my researches.

Q. Well now, have you made an analysis of the tests and the data appearing in this Bond patent, 2,200,532, in which he undertakes to support the theory of inhibition? Have you made an analysis and examination of the tests and data as shown there?

A. I have gone over the data very carefully and
545 I do not consider it establishes the fact that he has stated.

Q. Why do you say that, Doctor? What brings you to that conclusion or way of thinking?

A. Because there, first, is too great a variation in the data and the data is too scanty. The standard deviation in 5 is so great that the deviation doubled, that is, the amount of variation above and below the average, his lowest plot is less than the deviation, which is a very strong deviation where only this amount of data is presented.

Q. Well, now, Doctor, as a matter of fact there is a lot about these bacteria that even Mr. Bond and other scientists don't know, isn't there?

A. Very true.

Q. There is this symbiotic relationship whereby, in some instances, nitrogen fixation results when the bacteria is brought into association with the roots of a leguminous plant.

Just exactly what brings about that nitrogen fixation is a law of God or Nature that man doesn't know, isn't it?

546 A. We do not know what the actual facts are in causing the fixation. We have our theories, of course.

Q. (By Mr. Greer) Well, what would you say, Doctor, as to the same species of bacteria brought into association with the same species of leguminous plant under similar circumstances at the same time?

Would you or would you not necessarily obtain the same nitrogen fixation in those two instances?

A. In the best control that we have in laboratory technique we vary considerably.

Q. Do you know why that variation is occasioned?

A. We do not.

Q. Now, coming back to this question of literature, Doctor: I want to invite your attention to some articles which Mr. Bond, when on the witness stand, brought to the attention of the court, as I understand it, in support of his thesis that there is this condition of inhibition in connection with this bacteria and the host plant.

And the first article was by a German named Max
547 Kronberger, I believe it, if I pronounce it correctly; you understand the article that I mean.

A. Kronberger.

Q. Have you got a copy of the translation of that article, Doctor?

A. I have not the copy with me.

Q. How?

A. I have not the copy with me.

Q. I will hand you a copy of it (handing document to the witness). You have studied that carefully, have you,—gone over it?

A. I have, very carefully.

Q. What would be your statement after a careful study of that article as to whether or not it supports or does not support a thesis of inhibition in a plurality of strains of this genus Rhizobium?

A. I do not think that the article supports that.

Q. Now, will you tell us why you think that, Doctor?

A. Because the technique is not standard.

Q. The technique is not what?

A. Standard, general usage.

Q. Where does it violate any standard rules?

A. In the first place his period of sterilization of
548 the soil is too short.

The Court: Well, when you say his article doesn't support that theory, you mean that it doesn't effectively support it, don't you? It advances that theory all right, doesn't it?

The Witness: It advances the theory but the technique as we—

The Court: But the technique that he uses doesn't lend weight to it.

The Witness: Is not the standard technique to prove the facts he states.

Q. (By Mr. Greer) What do you mean by this period of sterilization he spoke of?

A. He speaks of sterilizing soil, a large quantity of soil for a period of 25 minutes at one atmospheric pressure, 15 pounds. Everyone who has worked in the field of soil bacteriology knows that that length of period,—the heat, the steam would not penetrate that soil to the depth necessary to make it sterile.

Q. What would be the effect of contaminating bacteria in the soil if it had not effective sterilization?

549 A. There may be nodule organisms of other types there, particularly other types that might influence the experiment considerably.

Q. What is the generally accepted, or do you know what is the generally accepted standard in this country of a period of sterilization and the temperature or pressure under which that sterilization is brought about?

A. The amount of soil that he uses, in my class room we have found it takes four hours to sterilize that amount of soil.

Q. Against the 25 minutes that he took?

A. Against the 25 minutes. Waksman tells us that it may be done in two hours but he doesn't tell us the amount of soil.

Q. Are there any other criticisms that you have to offer with regard to that article as being defective in its demonstration?

A. The type of soil that he uses is not standard in our technique for studying nodule organisms and their influence one upon another.

He uses 2600 grams of sand and 1000 grams of humus, with certain additions to it.

Q. Well, what about his method of sterilizing the seed?

550 A. He uses in the sterilization of the seed a chemical ten times as strong as we would recommend in our practice; that is, he uses a 1% corrosive sublimate where we would stay by 1/10th of 1% or we would prefer other methods.

Q. What would be the effect of using the strong solution that Kronberger used?

A. The strong solution that he uses would injure the seed, particularly the smaller seeds.

Q. By the way, Doctor, along this point of inoculating seed or soil, is there any difference in the functioning of the bacteria and the matter of inoculating the plant, whether you inoculate the soil that the seed is planted in or inoculate the seed before they are put in the soil?

A. Very little difference in our experiences.

Q. Both are standard, recognized practices, are they?

A. Both are. In the early days practically all of the inoculation was by soil.

Q. Well now, Doctor, I will ask you if you did any particular research work in connection with this symbiotic relationship of bacteria to leguminous plants? If so, when and under what circumstances?

A. I have been working with that problem for—you might say ever since I have been at the Delaware
551 Experiment Station, but during the years 1914, 1915 and 1916 we did some experimental work on humus as a carrier of beneficial bacteria.

Q. Well now, will you explain how you happened to do that particular work with humus as a carrier for bacteria?

A. We were working with commercial cultures of inoculants and found on the market many that were inferior and we believed that part of the trouble was the base that was used for carrying these inoculants.

Q. That what?

A. The base that was used—

Q. When you say "we" who are you referring to when you say "we"?

A. I mean several in my department who were working with me. The soil bacteriological work I refer to, and those who had been working with me have talked over these points.

Q. Now, was there any official report made of your research in work done in that connection?

A. Bulletin 115 from the Delaware Experiment Station,—Delaware College and Experiment Station, reports that work.

Q. And when was that published?

A. That was published in 1916.

552 Q. Published by the Delaware College of Agriculture, as I understand it?

A. I beg your pardon.

Q. It was published by the Delaware College of Agriculture?

A. Delaware College Agricultural Experiment Station.

Q. And what was done with it, in the matter of distribution?

A. It was generally distributed on the mailing list which goes to all the land-grant colleges and research institutions; also to the mailing list of the farmers of the state.

Q. Who prepared that report, Doctor?

A. I prepared that report.

Q. Is that a copy of the report as it was published in December, 1916 (handing paper to witness)?

A. That is a copy of the report as published in 1916.

Mr. Greer: The defendant offers in evidence this paper, published in 1916, and identified by the witness, as Defendant's Exhibit 16.

The Court: That was your report in the experiment on humus?

The Witness: Humus as a carrier of fertilizer and
553 beneficial bacteria.

The Court: It may be received.

(Said document entitled: BULLETIN No. 115, DELAWARE COLLEGE AGRICULTURAL EXPERIMENT STATION: "A PRELIMINARY REPORT ON MUCK HUMUS AS A FERTILIZER AND CARRIER OF BENEFICIAL SOIL BACTERIA" by Thomas F. Manns and Joseph M. Goheen, dated December, 1916 was marked Defendant's Exhibit 16 and received in evidence.)

Q. (By Mr. Greer) Now, Doctor, can you tell us whether or not that report deals at all with the matter of an artificial inoculant as to the bacteria that are specific to leguminous plants?

A. It does.

Q. Will you point out to us anywhere without going thru all of your report, Doctor,—will you point out to us specifically any portion that has to do with the matter of an inoculant—

A. Well, on page 25, second paragraph: "It has
554 been inferred by certain producers of commercial inoculants that the organism of each particular legume requires a culture medium slightly different from that of another and particularly adapted for the organism in question. Further, that the germs for one variety of legume will not work on any other variety of legume. In the light of recent investigations the present work shows that the organisms for the different groups of important agricultural legumes may be successfully carried in one and the same compost."

Q. What sort of an inoculant did you use in your experiments that you conducted that are mentioned in this report?

A. We used a humus in which the several legume organisms were put in in pure culture.

Q. It was then what we have been referring to, was it, as a composite culture?

A. It is a composite culture.

Q. Will you state whether or not there were a plurality of strains of the bacteria that were supposed to be specific to more than one cross-inoculation group of leguminous plants?

A. It was a composite of several of the cross-inoculation groups of Rhizobium of the legumes.

555 Q. Now, do you make any particular reference to that other than what you have just read in this report? If so, will you call our attention to the specific parts of your pamphlet showing that?

A. In this bulletin we have used sterilized sand for carrying on inoculation work with such a composite culture, using that sand according to standard practice and in that work we have shown that when the several groups, the alfalfa group, the clover group, the vetch, the cow peas, and the soybeans were used, we were able to carry these several groups in one and the same compost and produce different splendid inoculation.

"The splendid inoculation—"

The Court: What page?

The Witness: Page 27, the lower paragraph.

A. (continued) "The splendid inoculation produced in these sand cultures would indicate that such humus as was used in these experiments could be readily inoculated and composted so as to carry all the important organisms

for the inoculation of the different groups of important agricultural legumes."

Q. (By Mr. Greer) Now do I understand from that when you say the different groups,—the organisms for the inoculation of the different groups of important
556 agricultural legumes, that in this single inoculant you had the organisms, that means, does it, the bacteria?

A. That is correct, of the particular cross-inoculation group.

557 Mr. Greer: Q. And that bacteria was of the kind that was specific to these groups of plants consisting of alfalfa, clover, vetch, cow peas and soy beans?

A. Right.

Q. How many cross-inoculation groups do they embrace?

A. They represent five inocular groups.

Q. But, do you mean, Mr. Manns, that you put the inoculant from all of the different plants in the same humus at the same time?

A. At the same time. These were all grown separately as pure cultures and incorporated in the one humus as a composite inoculant.

Q. And then that was used to inoculate those five
558 different ones?

A. To inoculate those five different sand pots that were planted with five different legumes.

Mr. Greer: Q. Will you explain that a little further? What was put in each pot?

A. In each pot was planted a different group of legumes, clover in one, alfalfa in another, soy beans in another, cow peas in another and vetch in another.

Q. Is that shown anywhere in this report?

A. That is shown in figure VII, I believe.

Q. I call your attention to figure VII.

The Witness: (Continuing:) Illustrated in figure VII.

Mr. Greer: Q. Is it figure VII or Plate VII?

A. I mean in Plate VII, at the end of the booklet.

Mr. Greer: Q. Now, will you turn to that page, where Plate VII appears, and explain to His Honor what is shown there?

A. In the first series of pots—I think I have made it plain that these pots were sterilized for four hours,
559 at fifteen pounds pressure.

Mr. Greer: Q. Just what is shown in those pots? There are three series of pots there.

A. There are three series of pots here in which the amount of inoculant was varied, and we have based the variation on agar culture practice, as we say. There are 2,000,000 pounds in the furrow slice of an acre. That is the generally accepted statement of the 6-inch acre, 2,000,000 pounds. This varies slightly with the type of soil. If it is a clay soil, it is a trifle less. If it is a heavy soil—I mean if it is a sandy soil, it would be a trifle more. But usually there is no surplus. We put it on a 6-inch acre, and here we have used the inoculation on that 8 pounds of sand which is in the 7-inch pot; there is 8 pounds of sand. We have used 2 pounds of the compost at a 2,000,000 pound acre, or in actual figures there is .004 of one gram used in the first series of each of the pots, .004 of one gram—

Mr. Greer: I do not think it is necessary to go into that detail, Doctor.

The Witness: In the second series is the 100 pounds
560 at the 2,000,000 pound rate and in the third series 500 pounds at 2,000,000 rate.

Q. Will you tell us what was the result of the test that you had there in connection with the fixing of the nitrogen in the growth of the plant?

A. The result of the test in connection with the fixation throughout was splendid inoculation, as given on page 27, at the bottom of the page.

Mr. Greer: The defendant calls particular attention of counsel for the plaintiff that we are relying, of course, on all of this pamphlet, but we will have particular reference, in order to save time in looking through every page of it, to page 20 with regard to compost No. 25, page 22, compost No. 28 and compost No. 30, showing what the compost consisted of; this page 25—

The Witness: Compost 25.

Mr. Greer: (Continuing:)—and page 27 and page 40—well, page 39, paragraph 9, on page 39, page 40, with reference to Plate VII and the illustration of Plate VII; all of those will be particularly referred to.

Q. Now, Doctor, will you tell us how you prepared the inoculant which you used in these tests?

561 A. The inoculant which was used in these tests was prepared by getting pure cultures of each of the strains in which we were working on soy beans, cow peas, crimson clover and alfalfa. Pure strains of those were inoculated into a humus soil:

Q. Where did you obtain those strains?

A. Those strains were obtained in the sandy lands of lower Delaware, where we usually go for cultures of legumes to show efficiency. If they show high efficiency in those sandy lands, which are low in nitrogen, and the crop responds well, we consider that the inoculant must be good.

Q. Who isolated those?

A. I isolated those myself.

Q. And then after isolating the strains, what did you do with them?

A. Cultured them for propagation to be placed into a humus for inoculant.

Q. Was that culture a separate group or a composite group?

A. A composite culture of these four groups.

Q. Then what did you do after you had cultured them?

A. I inoculated the compost as stated in that 562 mixture there.

Mr. Greer: Your Honor understands what the word compost means?

The Court: It is just another word for the base?

Mr. Greer: That is the carrying medium, really is what it is.

Q. How was that compost inoculated?

A. How was it inoculated?

Q. Yes.

A. We used, in this particular compost, 2,000 pounds of culture, the raw material from the Alphano beds and with several other inoculants, plus the 25,000 pounds of inoculant.

Q. What if anything did you do with regard to the single strain prior to inoculating the compost?

A. I tested these several strains to see what they had.

Q. What was the purpose of that test?

A. Simply to see that they had the proper efficiency, as we would test every strain before using it.

Q. All right. Then, I believe you had gotten along to putting the inoculant in the compost. Then what did you do next?

A. We planted this, a 4-gallon pot containing 8 563 grams of this particular compost, and planted it with these several legumes that are mentioned here.

Q. And after the legumes grew, what did you do then?

A. At the end of the period that is given here, they

were planted on January 14th, 1916. They were removed from the pots on March 30, 1916, a little short of three months in there.

Q. Then what did you do with them when you removed them from the pots?

A. During the time of growth, we took notes as to how the legumes were appearing, whether they were healthy or not, and at the time of the expiration, we took the plants right out of the soil and examined them, for inoculation.

Q. How did you examine them, Doctor, for inoculation —I mean for nodulation?

A. We pushed the soil away from the roots and examined them visually.

Q. Visually?

A. Yes. The notes state that, under "Cow peas" "abundant, very large"; Soy beans, "good, large"; Crimson clover, "medium, small," nodules; and Alfalfa, "abundant, very large."

564 Q. Does that have any reference or not to nitrogen fixation?

A. It may have reference to it or may not, that is, if the particular soil is heavy, carrying plenty of nutrients for the plant, it may mean that there was very little fixation of nitrogen. If it was rooted in a sand series, it would mean, if your plant were showing very nice and green, that there was a heavy fixation of nitrogen.

Q. From your experience in this line, Doctor, can you tell from a visual examination, including the color of the plant and the general growth and development of the plant, anything at all as to whether or not there has been nitrogen fixation?

A. We can tell whether the plant has abundance of nitrogen in it, and if it is on light sandy land, we would draw the conclusion that the nitrogen is coming from nodule formation.

Q. Can one skilled in the art tell with any degree of accuracy as to that?

A. Yes. Anyone skilled in the art can tell with very great accuracy.

Q. Simply from the observation?

A. Yes, simply from the inspection.

565 Q. Now, can you tell us whether or not you made any comparison between the plants which were grown

in this compost, with a composite culture and the efficiency test as to the single culture which you stated you had made?

A. The single cultures were made in sand along with the sand series and in the sand the single cultures showed just about equal to and I could tell no difference so far as the eye could discern, between the single culture and the composite culture.

Q. Did you or did you not make that comparison?

A. I did make that test.

Q. After you had completed this work, Doctor, what did you do then with this inoculant? As I understood you, that inoculant was one you got up yourself, is that true?

A. That is true.

Q. Well, what did you do with it after that?

A. The work was being done under Fellowship with the Alphano Humus Company, and the Alphano Humus Company it once adopted the technique that we had shown for the production of a composite culture.

Q. Do you know what business the Alphano Humus Company was in?

566 A. The Alphano Humus Company was in the commercial game of selling humus from the deposit at Summit, New Jersey, where they had some 3,000 acres.

Q. Do you know whether or not they placed upon the market composite inoculant?

A. They did.

Q. And can you tell us when that was?

A. It was shortly after these experiments were conducted and was running as far as I can recall up to '23 or '4.

Q. By these experiments you refer in using that expression to the experiments in the bulletin?

A. Yes, sir.

Q. (Continuing:) Defendant's Exhibit Number 16, Bulletin No. 115?

A. That is right.

569 (And thereupon at about the hour of 5:20 o'clock P.M., on Wednesday, June 27th, 1945, an adjournment was taken until the following day, Thursday, June 28th, 1945, at the hour of 9:00 o'clock A.M.)

572 Q. Doctor Manns, I will hand you a document and ask you if you can state what that is (handing document to witness)?

A. This is a pamphlet put out by the Alphano Humus

Company describing their humus and its value as an inoculant and carrier of beneficial bacteria.

Q. Have you ever seen pamphlets similar to this pamphlet?

A. I have seen similar pamphlets.

573 Mr. Greer: Then we offer that publication as Defendant's Exhibit Number 17.

The portions of it that we particularly rely upon are pages 20, 21 and 23.

The Court: Any objection, Mr. Rathburn?

Mr. Rathburn: Yes, Your Honor, we object to the offer to this extent: We don't object to it as a publication, but it is an advertising booklet. We object to it so far as it proves any statements that are made about the use and sale. This public use by the Alphano Inoculant Company is not pleaded. The booklets are just pleaded as publications.

The Court: That is the sole purpose of this offer?

Mr. Greer: That is the sole purpose, to show that there was in 1916 a publication of the use of Alphano inoculant as a composite humus.

574 The Court: When was it published? I don't see any date.

The Witness: It was published following the research work upon Alphano humus.

The Court: What year?

The Witness: From 1916 to 1923.

575 The Court: It may be received in evidence for the limited purpose for which it is offered.

Mr. Greer: It is not offered for any other purpose than that of publication.

(Said booklet entitled "The Alphano Book", published by the Alphano Humus Company, Whitehall Building, 17 Battery Place, New York City, so offered, was received in evidence by the Court, and marked Defendant's Exhibit 17.)

Mr. Greer: Q. Now, Doctor, do you have a sample of the original humus you were working with in your 576 experiments in connection with this Alphano product?

A. I do have the original humus that were used in these composites.

Q. At what time?

A. During the research work from 1915 to the date of publication of Bulletin 115.

Q. And that is the same publication?

A. Bulletin 115, Delaware College Agricultural Experiment Station, December 1916.

Mr. Greer: Now, the defendant offers in evidence as Defendant's Exhibit 18 the sample just referred to by the witness.

The Court: It may be received.

Mr. Thiess: What was it?

Mr. Neuman: Is that the sample he said he made in 1916 or 1917?

Mr. Greer: That is what he said.

Mr. Thiess: We have a little difficulty hearing. Will you read it, please?

(The record as above recorded was read by the reporter.)

(Said bottle containing sample humus, so offered, was received in evidence by the Court, and marked Defendant's Exhibit 18.)

577 Mr. Greer: Q. Doctor Manns, do you know whether or not this Alphano inoculant that you just referred to was ever subjected to a test by the public authorities of New Jersey, the New Jersey Agricultural Experiment Station?

Mr. Rathburn: I object to that, Your Honor. There is no pleading of public use by the Alphano Company. That is not competent in this case.

578 Mr. Greer: Will Your Honor wait just a moment and let's see what the answer says. We have pleaded the Alphano book, which is the book Your Honor has there published by the Alphano Humus Company in 1916, and particularly pages 20 and 21 thereof as a publication showing prior knowledge, not prior use, but prior knowledge of the idea of a composite culture. Now, we are proposing to offer a test by the New Jersey Department of Agriculture on the product which is mentioned in the book which we pleaded as prior knowledge.

The Court: You want to follow this question up with a showing of some sort—

Mr. Greer: That it was a satisfactory article.

579 The Court: (Continuing:)— of what it contained, of its use?

Mr. Greer: Of its use as a satisfactory article.

The Court: Well, why doesn't that bear on the question of knowledge? The knowledge that is conveyed by

this, the article itself must bear some relation to your product in order to be of any importance as knowledge.

Mr. Rathburn: That is pleaded as evidence of prior knowledge.

The Court: Yes.

Mr. Rathburn: It has to stand on its own feet when it is pleaded as a publication of prior knowledge.

The Court: Why not permit him to show what is in it?

Mr. Rathburn: If he wants to prove what is in it, we don't object, but he starts proving somebody placed it on the market when it isn't pleaded.

The Court: Your objection goes to the fact he is not permitted to show the use of it?

Mr. Rathburn: That is correct.

The Court: With that in mind, I will let him answer the question because I think that particular objection is sound.

Mr. Greer: As a public use, yes.

The Court: Well, it is not being received for that
580 purpose.

Mr. Greer: No.

The Court: Do you have the question in mind, Doctor?

The Witness: That is, have I seen reports from the New Jersey Experiment Station showing the results of Alphano humus? Practically that, not verbatim.

The Court: Is that your question?

Mr. Greer: Except Alphano inoculant instead of humus is the only difference.

The Witness: Inoculant. I have seen such report.

Mr. Greer: Q. I will hand you a document and ask you to state what that is (handing document to witness)?

A. This is a report from the New Jersey Agricultural Experiment Station showing the results of seed and legume inoculant inspection for 1922.

Mr. Greer: The defendant then offers this bulletin 377 of the New Jersey Agricultural Experiment Station as Defendant's Exhibit 19 with particular reference to pages 67 to 70, inclusive.

581 Mr. Rathburn: We have no further objection with the understanding that it is offered only in connection with Test Number 240, which appears on page 70 of the bulletin. There are many, many other tests in here that have no relation.

Mr. Greer: I think there is another one in there. It
582 is 274 and 240 on the same page. It refers to the same inoculant. The first one.

The Court: Is that agreeable? It may be marked and received in evidence.

(Said Bulletin 377 of January, 1923, entitled "Results of Seed and Legume Inoculant Inspection for 1922," "New Jersey Agricultural Experiment Stations", "Department of Seed Analysis", "New Brunswick, N. J." so offered, was received in evidence by the Court and marked Defendant's Exhibit No. 19.)

Mr. Greer: Next, may it please Your Honor, we offer in evidence a volume of some of the prior art patents which are pleaded in the answer as anticipation.

First is the Earp-Thomas Patent No. 865,965.

The Earp-Thomas Patent No. 1,099,121.

583 The Bottomley Patent No. 1,106,275.

The Earp-Thomas Patent No. 1,252,332.

The Earp-Thomas Patent No. 1,309,723.

The Thomas Franklin Manns Patent No. 1,320,701.

Mr. Greer: The defendant wishes to introduce this volume of patents as Defendant's Exhibit 20.

The Court: They may be received.

(Said volume of prior art patents, as hereinbefore described, so offered, was received in evidence by the Court, and marked Defendant's Exhibit No. 20.)

Mr. Greer: Q. Now, Dr. Manns, as I understand you, you have made a careful study and examination of the Bond Patent in suit here, have you not?

A. I have, sir.

Q. Do you have a copy of the volume of these patents which we have just mentioned as being introduced?

A. I have.

Q. I will ask you to turn to the Earp-Thomas Patent Number 865,965. Have you examined and studied

584 that patent?

A. I have.

Q. Will you state whether or not you find in that patent any teaching, showing or disclosure of a composite culture comprising different strains of different bacteria of the genus Rhizobium in the inoculant of soil or leguminous plants? That is the Earp-Thomas Patent No. 865,965.

A. I find such reference of a composite culture with a plurality of nitrogen fixing bacteria of the Rhizobium group.

Q. Will you point out to the Court where that showing is made in this patent?

A. It is shown on page 3, column 1, line 57, continuing on column 2 to line 76.

Mr. Greer: Q. What is said there that makes that disclosure, Doctor?

The Witness: May I read?

The Court: Yes.

The Witness: (Reading:)

585 "In the above description, I have assumed that the medium in the distributing vessels is inoculated with one kind only of the nitrogen gathering bacteria. However an important feature of my invention consists in inoculating the medium in each distributing vessel with a plurality of kinds of nitrogen gathering bacteria as will now be more fully explained. To do this, I first form a composite colony of a plurality of kinds of bacteria, by inoculating some medium in a suitable vessel with cultures taken separately from the different stock cultures, thus combining in one culture bacteria suitable for different kinds of plants. After this composite stock culture has been formed, the distributing vessels are inoculated from it whereby instead of each distributing vessel containing only one kind or variety of the nitrogen gathering bacteria, it contains a plurality of kinds. Consequently, such a culture is suitable for use in inoculating the seed of anyone of the kinds of plant from which the bacteria were originally obtained."

586 Mr. Greer: Now, Doctor, will you turn—

The Court: Just what patent is this? Can you tell without going into detail, just generally?

Mr. Greer: It relates to the art of growing and distributing nitrogen gathering bacteria. He says in the first part:

"My invention relates to improvements in the art of growing and distributing nitrogen gathering bacteria."

He teaches he gets them from nature and cultures them and then puts them in a carrying medium or base for use in the growth of plant.

Q. Now, Doctor, will you turn to the Earp-Thomas

Patent No. 1,099,121 and tell us first what that patent relates to?

A. This Earp-Thomas Patent No. 109,912—

The Court: 121.

Mr. Greer: 121.

The Witness: 121. (Continuing:)— shows "Means for Distributing Soil Bacteria".

Mr. Greer: Q. Now, do you find in that patent, Doctor, any teaching, showing or disclosure of the use of a composite culture?

A. Yes, there is shown the use of a composite
587 culture for inoculating soil.

Q. Will you please point out where that is shown and read it into the record?

A. This is shown on page 2, column 1, line 57 to column 2, line 74. May I read it into the record?

> "Soil for inoculating land for growing a particular species of legume may be inoculated with only the particular kind of variety of nodule-forming bacteria corresponding to the particular legume; or the soil may be inoculated with the various kinds or varieties of nodule-forming bacteria belonging to the commonly used legumes, either by inoculating with separate cultures of each different variety of the bacteria or with a composite culture containing the various varieties of these nodule-forming bacteria with which the sterilized soil is to be inoculated. Such composite cultures for inoculating the soil may be produced as set forth in United States Letters Patent No. 865,965, granted to me September 10th, 1907."

588 Q. Doctor, I will ask you to look down lines 87 on the right-hand or second column of page 2 of this patent, and read into the record what the last sentence of that patent is.

A. This is the second patent you are speaking of?

Q. Yes, sir.

A. Give me the lines again, please.

Q. Line 87, in the same paragraph from which you have been reading, and the last sentence in that same paragraph on the right-hand column.

A. (Reading)

> "For example, soil inoculated with bacteria specific

to red clover would answer for inoculating land for
589 growing alsike or white clover."

Q. The red clover, alsike, and white clover belong to the same cross-inoculation group?

A. Yes.

Q. Now, Doctor, what have you to say as to any fundamental difference in inoculating a soil and inoculating the seed of a plant?

A. There is practically no difference as far as reaching the end to be obtained. Both have been in use for many years.

Q. In other words, I understand from that that the functioning of the bacteria is the same?

A. The functioning is the same.

Q. It is a mere matter of convenience as to whether you use one method or the other. Now, I will ask you to turn, Doctor, to the Earp-Thomas Patent 1,309,723—
590 Do you find, Doctor, any teaching, disclosure, or showing of the use of composite culture in that patent? If so, where do you find that showing and tell us what it is. In order to save a little time, I call your attention to page 2, the first column.

A. On page 2, column 1, line 61, to page 2, line 71, we find reference to this—

The Court: You mean column 2, line 71?

The Witness: Column 2, line 71.

The Court: All right.

The Witness: (Continuing) —we find reference to this composite culture.

Mr. Greer: Q. And what does it say?

A. (Reading)

"Virulent cultures of the various bacteria required,
591 either pure or mixed, can be prepared to best advantage by methods set forth, for example, in my prior Patents Nos. 816,850 and 865,965; and inoculation of the prepared peat and phosphate rock mixture therewith can be effected by suitably diluting the agar-agar or other original culture with water, and sprinkling it upon the mixture, which is thoroughly stirred meanwhile."

Q. Now I will ask you to turn to the patent of Thomas Franklin Manns, of Newark, Delaware, No. 1,320,701. Are you the Thomas Franklin Manns of that patent?

A. I am.

Q. What, if any, connection did that patent have to do with the work concerning which you have testified and referred to in the bulletin, No. 116, Defendant's Exhibit 16?

A. The patent is the outcome of the research covered in that bulletin.

Q. Now, what does that patent relate to, Doctor?

A. It relates to the process of reinforcing, bacterizing, and composting organic material for use as in-
592 oculators, improvers, and fertilizer of soils.

Q. Where, if anywhere, do you find in that patent any teaching, showing, or disclosure as to the use of a composite culture in the inoculation of leguminous plants?

A. This is shown on page 2, column 2, lines 69 to 97.

Q. And how is it shown there?

A. May I read?

The Court: Yes, sir.

The Witness: (Reading)

> "Recent scientific knowledge (Bulletin 184, Kentucky Aug. 1914) and (Centralblatt fur Bakt. 40 Bd. No. 11-13—Mar. 1914) has shown that there are only nine species of B. radicicola—"

Mr. Greer: Q. May I interrupt you right there, Doctor? What is meant by that term "B. radicicola"?

A. It was the earlier name applied to the Rhizobium species.

Q. Bacteria?

A. Yes, bacteria. At that time the one term was supposed to cover all the—
593 Q. All right. Now proceed with your reading.

A. (Continuing)

> "——and six of these species or physiological groups cover the inoculation of the most important agricultural legumes. So in practice I employ thoroughly inoculated soil from a legume of each of the six groups, thereby introducing inoculation for all the important agricultural legumes in the one compost. In practice this material has been found superior to the so-called 'pure culture legume inoculating material'. In practice, when it is difficult to obtain the soil well inoculated for the particular legume, I use a pure culture for the same purpose, though the soil gives superior results. In practice I find this product to give thorough inoculation to the following legumes,

viz: alfalfa, sweet clover (white), sweet clover (yellow), black medic or yellow trefoil, bur clover, red clover, mammoth clover, alsike clover, white clover,
594 soy beans, cow peas, sweet peas, spring vetch, garden peas, Canada field peas, lima beans, navy beans, velvet beans, and the various other legumes commonly grown as soil improvers."

Q. Now, Doctor, these six groups that were referred to, state whether or not they are the same groups that are referred to in the Bond patent 2,200,532, on page 1, the right-hand column, beginning with line 30, that he calls there Rhizobium meliloti, Rhizobium trifolii, Rhizobium leguminosarum, and all the rest of them. I will stop there.

A. They are, I believe, the same groups.

Q. Now, just one more question, Doctor. You have been present in the courtroom when the testimony was being delivered here, I believe, have you not?

A. I have.

Q. And you have heard this discussion about garden cultures and field cultures, or garden size cultures and field cultures, have you not?

A. I have.

Q. Will you please state to the Court what your
595 opinion is as to whether or not there is any difference in the functioning and action of bacteria in a mixed garden size culture over a mixture of field size culture.

A. There is no difference, as far as I can see, in the functioning of these bacteria.

Mr. Greer: No further examination.

Cross-examination by Mr. Thiess.

Q. Doctor Manns, as I understand it, since 1912 you have been at the University of Delaware teaching, is that correct?

A. Correct.

Q. And since that time you haven't been associated in any way with the manufacture and production of commercial inoculants?

A. That I have or haven't been?

Q. Have not.

A. I have taken samples from the shelves for examination.

Q. Just a minute, will you answer my question? I

asked you whether you were connected with the
596 manufacture.

A. Not in any way except in the research—

Q. Well, if you will please answer my questions now.

The Witness: Except in the case of humus studies of Alphano peat, in which I manufactured and experimented with such cultures.

Mr. Thiess: Q. You say since 1912 you manufactured cultures?

A. Manufactured inoculating cultures for legumes.

The Court: Not for commercial use, or were they for commercial use?

The Witness: Part of the last batches made were turned over to the Alphano Humus Company.

The Court: All right. I think that is what you were getting at.

Mr. Thiess: That is what I was getting at.

Q. And how much of this inoculant did you make that you turned over to the company?

A. Something like 50 pounds.

597 Q. Just 50 pounds. And you made no other inoculant commercially since 1912 except this 50 pounds which you are talking about?

A. None whatever. Not commercially.

Mr. Thiess: Q. Now, Mr. Manns, what in your opinion is the minimum temperature that is necessary to kill root nodule bacteria and the minimum amount of time required for said temperature? Now, please just give me the temperature and the time.

A. This will vary from slightly above about 70 degrees centigrade, somewhere in there,—

Q. And for how long?

A. — to 75.

Mr. Thiess: Q. Well, you say that the temperature varies from 70 degrees to 275 centigrade.

A. 70 to 75.

598 Q. And how long did you say—what was the minimum time that it would require, at 70 to 75 degrees centigrade, to kill root nodule bacteria?

A. It may be done in 10 to 15 minutes, if properly exposed.

Q. If what?

A. If properly exposed.

Q. Well, I am referring to it being necessarily
599 properly exposed. That is, it is subjected to this temperature. That would be properly exposed, would it not?

A. Right.

Q. And you say it would kill these bacteria in 10 minutes?

A. Yes.

Q. Now, you have referred to the Kroenberger article, do you remember that?

A. I do, yes, sir.

Q. And isn't it a fact that Kroenberger, in his tests, used control pots?

A. Used the what?

Q. Control pots?

A. Explain what you mean by the control pot.

Q. Uninoculated control pots.

A. Yes.

Q. The answer is that he did use them?

A. He did use them.

Q. Now, did not all of his inoculated pots show a substantial increase in growth over his controls, in the Kroenberger article?

600 A. Slight amounts.

Q. You would not say it was substantial?

A. In most of the work, only slight amounts.

Q. Well, are there any indications of a substantial growth, in this Kroenberger article?

A. In some of the legumes, but in the red clover varying amounts; that is, almost within experimental error.

Q. Well, would you say there was none of them that showed substantial growths in the red clover?

A. I would say there is not substantial growth, no.

Q. Is your answer to my question yes or no?

A. No.

Q. Now, you find some additional growth in these pots, and doesn't this fact show, that the additional growth came from the legume bacteria applied and not from the legume bacteria left in the pots because of insufficient sterilization?

A. I would answer that no.

Q. Your answer to that is no. And why?

A. Because the technique is faulty.

Q. Now, the technique is faulty. What particular 601 part of the technique do you refer to now?

A. The sterilization of the soil in the pots, the technique applied to—

Q. Now, just a minute. On that first one, didn't you

just tell me that you could kill all the legume bacteria when they were exposed to a temperature of 70 degrees centigrade and kept there for a period of 10 minutes?

A. I said that.

Q. Well, don't you find the equivalent conditions in Kroenberger?

A. No. He has taken a large amount of soil, sterilized it 25 minutes at 15 pounds pressure. It is impossible for the heat to penetrate that amount of soil and kill the bacteria.

Q. What temperature do you get on steam for 15 pounds pressure above atmospheric?

A. About 250 Fahrenheit.

Q. And can you give it to me in centigrade?

A. About 220 centigrade,—120 centigrade, I mean.

Q. And it is your position that 220 degrees centigrade as used—I beg your pardon, 120 degrees centigrade,
602 as used by Kroenberger, would not sterilize the soil?

A. It would not, no, sir.

Q. And would not kill the legumes in the soil?

A. No, sir.

Q. And you base that on the fact that if that temperature is applied to the soil—for how long by Kroenberger?

A. 25 minutes.

Q. —for 25 minutes, the heat would not penetrate into the soil far enough?

A. It would not.

Q. And have you made any experiments to determine this?

A. I have.

Q. This particular thing?

A. You say that particular thing. We have dealt with all types of soil and peat combinations.

Q. Well, did you use soil of the type that Kroenberger had, and did you subject it to the temperatures and pressures and time that Kroenberger specifies, and did you find that you didn't get steriliz ion of that sort?

A. Practically so.

603 Q. When you say "practically so", what do you mean by "practically so"?

A. I mean practically the same type of soil, the same volume of soil, the same amount of heat, the same length of heat.

Q. And you say that under those circumstances you did not kill the legume bacteria?

A. No, sir.

Q. Have you got any of those tests available?

A. I have not here.

Q. Where were these tests made?

A. Made at the University of Delaware.

Q. And are the tests available there?

A. They are tests that are given to class work throughout—

Q. No, I am asking you whether these tests are available, that you said you made.

A. We have data that—

Q. Can't you answer that yes or no?

604 The Witness: We have data to show that in the length of time given the soil would not be sterilized to kill the legume bacteria.

Mr. Thiess: Q. And you brought none of that data with you?

A. I brought none of that data with me.

Q. You knew that you were going to make this assertion, did you not?

A. No, sir.

Q. You did not know that you were going—

A. I did as soon as I arrived but not at the time I left the University.

Q. Just a minute.

A. Or I would have brought the data.

Q. What was the last statement?

A. I say, not at the time I left the University.

Q. To come here to testify?

A. Yes.

Q. And you had not studied the Kronberger articles before then?

A. No, sir.

Q. You had never seen it?

605 A. Never seen it.

Q. And when did you first look at the Kroenberger article?

A. Since I have been here this week.

Q. Did you look at it the first day you were here?

A. I think probably on Saturday evening or Monday evening.

Q. And after you had read the article you knew that

you were going to make this objection to the Kroenberger tests?

A. I did.

Q. But you made no attempt to get those tests from the University?

A. No.

Q. Now, did you at any time prior to August, 1936, commercially produce and sell the inoculant discussed in your bulletin, Exhibit 19, outside of the 50 pounds you referred to?

A. Did you use the word "sell"?

Q. I said, did you make or sell?

A. Make or sell?

Q. Yes.

606 A. I have made none other than the amounts necessary for the research work, and that which was turned over to the Alphano Humus Company.

Q. And that was the 50 pounds that you mentioned before?

A. Yes.

Q. Did they use that for research work?

A. I beg your pardon?

Q. Did they use that for research work?

A. I could not tell you that.

Q. And would your answer be the same with respect to the inoculant described in your patent that you have referred to?

A. Would the answer be the same?

Q. Yes.

A. That is, that I had not manufactured?

Q. That is right.

A. Or sold?

Q. That is right?

A. Correct.

Q. Now, with respect to this bulletin, Defendant's Exhibit 19, were the tests referred therein—or put

607 it this way: These tests that are referred therein merely show that nodules were formed on the plants, is that correct?

A. It shows that satisfactory inoculation was performed.

Q. Well, that was determined by showing that nodules formed on the plants, was it not?

A. All I have is the report of the New Jersey authorities, and it said they were O. K.

Q. Well, then you don't know how it was done?
A. No, sir. I know the general practice which is used by standard laboratories.
608 Q. But you don't know how these tests were made?
A. No.
609 Q. Now, Dr. Manns, had you, prior to August, 1938, made any search of the scientific literature to determine what information was given as to the effect that mixing different species of Rhizobium would have on the nitrogen fixing ability of every species so mixed?
A. Of every species, did you say?
Q. —so mixed, yes.
A. I have covered the literature fairly carefully. It does not cover every species.
Q. Well, for most species, then.
Mr. Thiess: Change the question to read: for most species.
A. I would say for agricultural species, but not most species.
Q. (By Mr. Thiess) Now, you say you have read the literature?
A. I have read the literature.
Q. You made that sort of a search?
A. I have made that assertion.
Q. You have made that search.
A. I have made that assertion that I have gone over the literature and I am familiar with it.
Q. And when did you make that search?
610 A. From time to time as the literature accumulated.
Q. Oh, in other words, this statement that you are giving me is that you read the literature as it came along and you consider that making a search for this purpose, is that correct?
A. I familiarized myself with the literature as it came out.
Q. So your answer to my question is Yes?
A. Yes.
Q. Now, with respect to this search, can you give me the articles that you know of which are pertinent to this subject matter?
A. There are references—
Q. I don't want a general statement. I want specific references to articles.
A. I cannot give you the exact page and so on, but

Waksman calls attention to it in his book: "MICROBIOLOGY".

Q. How do you spell that?

A. M-i-c-r-o-b-i-o-l-o-g-y.

Q. And what does Waksman say?

A. Waksman refers to it in two places; in one place, speaking of types of organism with one another, possible influence and others, that they do not, is my memory of it.

611 Q. You didn't bring this book with you?

A. No.

Q. Did you know your were going to make this sort of an assertion when you came here to the trial?

A. Not fully, no.

Q. When you say "not fully", what do you mean by that?

A. Covering the literature upon this particular item.

Q. Didn't you know that you were going to expert this art in this patent for some time?

A. I beg your pardon.

Q. Didn't you know that you were going to expert in this trial, and expert this prior art in this patent for some time?

A. Pertaining to the Bond patent, I would say Yes.

Q. And haven't you spent time with your counsel, going over this?

A. Some time, yes.

Q. When you say "some time" haven't you spent some real time with him?

A. A certain amount of time. I wouldn't say any great amount.

Q. Well, you have spent time to go over all this material with him, haven't you?

612 A. Certain amounts of it, certain amounts of literature.

Q. Can you give me any idea how much time you spent with him?

A. On this particular—

Q. No, getting ready to expert in this case.

A. Since Saturday only evenings.

Q. Didn't you talk to him before Saturday?

A. Not with Captain Greer.

Q. Did you talk to somebody in his office?

A. I have had several talks, yes.

Q. With whom?

A. With Mr. Staley.

Q. And you had a number of talks with him prior to that date, did you not?

A. Yes.

Q. And how much time did you put in with Mr. Staley?

A. Pertaining to this item, very little.

Q. I am not asking as to this item. I am talking about generally experting this patent.

A. Possibly parts of two days.

Q. And you have known for how long that you were going to expert this patent?

A. Since some time the past summer.

613 Q. And under those circumstances you knew the points that you were going to make and you could have brought the literature with you, for instance, this book you are now referring to, could you not?

A. I could.

Q. Now, have you got any other literature that you could refer to specifically at the present time that would show this?

A. I have read other summaries dealing with this.

Q. The general statements I am not interested in, Dr. Manns; I want specific references.

A. I have not brought them with me.

Q. Now, here is the Waksman book (handing book to the witness). Will you please point out in this book the two references you have referred to?

A. This is not the book that I referred to.

Q. What is the book that you referred to?

A. "Microbiology".

Q. Is that an earlier book by Waksman?

A. I think it is. What is the date of that one?

Q. 1945.

A. Yes; it is very much earlier.

Q. And you don't believe that that statement is 614 in this later book?

A. I don't know.

Q. You have never read this book?

A. I haven't read this particular book.

Q. Have you read this later book of Waksman?

A. Not fully.

Q. Have you read any of it?

A. I would say that I have not gone over that book.

Q. Have you seen it before?

A. I have seen it but I have not studied it.

Q. Now, in criticizing the Kronberger article you referred to the fact that he used too strong a solution to sterilize his seeds and you stated, referring to—

A. Not sterilize the peat with the solution—

Q. Will you just wait a minute? And you stated in answer to the question: "What would be the effect of using the strong solution that Kronberger used?"

"A. The strong solution that he used would injure the seeds, particularly the smaller seeds."

Now, it is a fact, is it not, that these seeds in the Kronberger experiments germinated in all the pots, including the control pots?

A. He does not give us the amount of germination.

615 Q. But isn't it a fact that they grew?

A. He says they grew but he does not give us the number nor the percentage of growth.

Q. In this Bulletin 115 that you have referred to, did you give the percentage of germination in respect to your experiments?

A. I did not in the sand cultures.

Q. Well, did you give it as to any of them?

A. The experiment as set up in my work covered for the sand cultures 20 of the smaller seeds and 10 of the large to be left in the pots.

Q. Well, what I am asking you, Dr. Manns, is whether in this report of yours you gave the percentage of germination of seeds?

A. I brought mine to a standard—

Q. Can't you answer that question Yes or No?

A. I would say No.

Q. Well; then, if you didn't give it in your tests, why do you criticize Kronberger for not giving it?

A. Because he does not give us the facts pertaining to the seeds, numbers grown.

Q. Well, you didn't give it in your reports; your reports would be subject to the same criticism, would

616 they not? Can you answer that Yes or No?

A. Yes.

Mr. Thiess: That is all on that.

Q. (By Mr. Thiess) Now, on pages 560 and 561 of the transcript of the record, you were asked this question and gave this answer:

"Q. Now, Doctor, will you tell us how you prepared the inoculant which you used in these tests?"

and the answer:

"A. The inoculant which was used in these tests was prepared by getting pure cultures of each of the strains in which we were working on soy beans, cow peas, crimson clover and alfalfa."

Where did you describe that statement in your Bulletin 115, Defendant's Exhibit 16?

A. The description is not given there, as far as I recall.

Q. It is not in your Bulletin?

A. Not in the Bulletin.

Q. Now, doesn't your Bulletin record that inoculation was carried out by using soil, and I refer you particularly to page 6 of that Bulletin?

A. The inoculation was placed in the soil.

Q. Will you kindly read from the Bulletin where 617 it states that, what you have just said?

A. You are speaking of two different types of work here.

Q. Well, will you answer that question first, and then you can explain your answer, if you so desire?

A. State the question again, please.

Q. And I had referred you to page 6.

A. You are referring to page 6?

Q. No, any place in the Bulletin. I thought I would help you by giving you page 6.

A. Dealing with page 6, we are dealing with a series of composts that have nothing to do, whatever, with the inoculant used in the sand cultures.

Q. Can you find that statement at any other place in the Bulletin, referring to inoculants?

A. On page 27: "five different legumes were employed—"

Q. Just a minute. Where did you start reading, on page 27?

A. Page 27, on the 5th line.

A. (reading) "5 different legumes were employed representing as many different nodule organism groups, 618 i.e., alfalfa, clover, vetch, cow peas and soybeans. This work was done in duplicate."

Q. Now, the statement that you have just read,—that refers to the fact that these legumes were placed in the compost that you have referred to, is that correct?

A. These legume cultures were placed in a base that we considered an efficient carrier for inoculant.

Q. And this compost, that is a very heavy fertilizer, isn't it?

A. A very—

Q. A very efficient fertilizer?

A. This compost is a very efficient fertilizer?

Q. Is that correct?

A. I would say No,—not correct.

Q. Well, you made quite a bit of this particular compost, having found a bed of it somewhere?

A. Having found which?

Q. Having found a bed of this compost somewhere?

A. The material was sent me from Summit, New Jersey, as dug from the original beds.

Q. And you considered that very good material to grow seeds in, did you not?

A. As used for trucking?

619 Q. As used for trucking?

A. Yes.

Q. By that you mean for vegetable gardens, etc.?

A. Yes.

Q. And it was used for that purpose and sold for that purpose, was it not?

A. Used for what purpose?

Q. Trucking purposes?

A. The original grounds were. Where the muck was dug from depths of five or six feet, it may or may not include that area.

Q. And that was the muck that you used in your fertilizer referred to in your Bulletin and in your main patent, is that correct?

A. As the basis of the compost, the raw peat as we get it.

Q. Now, this statement that you read from page 27 of your Bulletin 115 refers to "5 different legumes were employed". That isn't referring to the bacteria, is it?

A. Yes, sir, the cultures of bacteria.

Q. Well, it says: "5 different legumes were employed

representing as many nodule organism groups". You say that refers to bacteria?

620 A. That refers to cultures taken from those legumes.

Q. Going down a little further, dropping down about four or five lines where you state: "The appearance of the legumes was somewhat better where 100 pounds and 500 pounds respectively of the composts were used."

A. Correct.

Q. How were you using legumes there?

A. The compost base that was used for the inoculant.

Q. I am merely asking you how you are using the word "legumes" there in this second quotation.

A. In the sand pots showing the inoculation—

Q. Does "legumes" in that second quotation refer to the plants?

A. Absolutely.

Q. Why do you say that it refers to the plants in the second quotation and legume bacteria in the first quotation when you use the same word?

A. Because we are speaking of the source of cultures in the first.

Q. Where do you get the idea that you are talking about the source of cultures? Will you please point out in that sentence—

A. We are dealing with five different groups.

621 Q. You say five different legumes were employed.

A. Representing as many as five different nodule organism groups.

Q. But you are referring to the plant groups of the legumes; you are not referring to bacteria.

A. We are referring to cultures taken from those groups.

Q. And you say that that language says that. That is your position?

A. That is my position. I did the work.

Q. Now, on page 562 of the record you refer to the pots and you say:

"We planted this, a 4-gallon pot containing 8 grams . . of this particular compost, and planted it with these several legumes that are mentioned here."

A. 8,000 grams.

Q. Yes; that should be 8,000 grams, should it not?

A. Yes, sir.

Q. And the bacteria were contained in those 8,000 grams, is that correct?

A. I beg your pardon.

Q. And the bacteria were contained in those 8,000 grams of compost?

A. It was. You mean the ones that were used in the inoculant?

622 Q. Yes, the seeds that were inoculated were put in this 8,000 grams of compost.

A. No, sir.

Q. What did you put in that 8,000 grams of compost?

A. This 8,000 grams of compost refers to a series of composts, some 30, which had to do with the preparation of a proper base.

Q. All right; let us see what your testimony says:

"A. Simply to see that they had the proper efficiency, as we would test every strain before using it.

"Q. All right. Then, I believe you had gotten along to putting the inoculant in the compost. Then what did you do next?

"A. We planted this, a 4-gallon pot containing—"

and you now say 8,000—

"A. (continued)—8,000 grams of this particular compost, and planted it with these several legumes that are mentioned here."

Now, what do you mean by that?

A. This is dealing with composts and not with a test for inoculant in seeds.

Q. Well, I didn't ask you that; I asked you whether 623 you didn't plant these inoculated seeds in this compost, in these 8,000 grams.

A. Not the inoculated seeds.

Q. Well, what did you put in there?

A. This crude, this raw peat, 8,000 grams, was composted with various amendments to which 25 pounds per ton,—at the rate of 25 pounds per ton of a soil inoculant was added.

Q. And then you put the seeds in that combination, is that correct?

A. In these several composts that were variously amended, yes.

Q. Well, it is a fact in your experiments you filled the jars with composts, do you not?

A. Nearly filled.

Q. And then you inoculate the seeds, do you not?

A. No, this had nothing to do with inoculating the seed. The compost was inoculated with 25 pounds,—at the rate of 25 pounds per ton.

That has nothing to do with the studies further on dealing with an inoculant for seed.

Q. Then you inoculated the compost?

A. Correct.

Q. And then you planted the seeds in the inoculated
624 compost, is that correct?

A. Correct.

Q. I want to refer you to this page 563.

The Court: You are speaking of the record in this case?

Mr. Thiess: Yes; the record in this case.

Q. (By Mr. Thiess—continued) At the bottom of the page, you refer to certain tests that you made, and you say,—you answered the following questions as follows:

"Q. How did you examine them, Doctor, for inoculation—I mean for nodulation?"

And your answer:

"A. We pushed the soil away from the roots and examined them visually."

A. Washed the soil away, it should be.

Mr. Thiess: All right; we will take that amendment.

Q. (reading):

"Q. Visually?

"A. Yes. The notes state that, under 'Cow peas' 'abundant, very large'; Soy beans, 'good, large'; 'Crimson clover', 'medium, small,' nodules; and Alfalfa, 'abundant, very large'."

Now, those results were obtained in using an inocu-
625 lated compost, were they not?

A. Correct.

Q. That did not refer to the sand test that you have in your Bulletin?

A. That was not for what?

Q. That did not refer to the sand test that you referred to in your Bulletin?

A. No, sir.

Q. Now, in your yesterday's testimony referring to your tests, page 564 of the transcript, you said:

"If it was rooted in a sand series, it would mean, if your plant were showing very nice and green, that there was a heavy fixation of nitrogen."

As a matter of fact, Dr. Manns, your plants were planted in a soil carrying plenty of nutrients and not in sand, is that correct?

A. Are you speaking of the sand inoculation?

Q. I would like to refer you to page 20 of this Bulletin, the test of 25. It was the test we were just talking about.

A. I have it right here.

Q. Have you got the page?

A. Yes.

Q. Your answer is Yes, is it?

626 A. That there was plenty of nutrient,—is that the question?

Q. Yes.

A. Sufficient for fair growth.

Q. That there is plenty of nutrient and they are not planted in sand?

A. Correct.

627 Mr. Thiess: Dr. Manns, have you the Bond patent in suit, there?

A. I have a copy.

Q. Now, will you refer to page 6 and the table contained on that page?

A. Yes.

Q. Now, there is, is there not, a significant difference as between series 2 and 4 reported in the table of the Bond patent, both of these series having strains of clover bacteria?

Mr. Rathburn: The same strains.

Mr. Thiess: Q. (Continuing:) Well, make it the same strains of bacteria?

A. There is a significant difference, is your statement?

Q. Yes. I said there is a significant difference reported in that table?

A. There is reported, yes.

Q. And if there is such a significant difference, then, the table demonstrates an inhibition or reduction, does it not?

A. I would say the data is too scanty to show that.

Q. Can't you answer my question, which is based on the previous question?

628 The Witness: Would you kindly point out where he says or it states a significant difference?

Mr. Thiess: Q. I am asking you whether that table does report a significant difference.

The Court: That is, between series 2 and 4?

Mr. Thiess: Yes, and he just said that the table did report a significant difference, and then my present question is:

Q. If this table does report such a significant dif-
629 ference, then, the table does demonstrate an inhibition or reduction due to it, does it not?

The Witness: I didn't understand the question as first put to me.

A. I would say that the table as set up does not give significant difference.

Mr. Thiess: Q. Does it report a difference?

A. It reports a difference.

Q. Well, why do you say it is not significant?

A. Because it does not, in my judgment, meet the standard tests for significance.

Q. And will you qualify that a little bit more? I don't know what you mean by that, the standard test for significance?

A. Well, we have several tests, and the data, to me, appears—

Q. I am confining it to the data on the table. Does the table as set out in the patent indicate a significant difference; between 2 and 4, you understand that?

A. Between 2 and 4? Between 2 and 4?

Q. Yes. What about it, is there a significant difference reported in the table?

A. It is reported in the table—that is, it is not
630 reported, but it indicates there.

Q. All right. Now, that being the case, if there is a significant difference reported, as you have just stated there is, then that demonstrates, does it not, as far as what

is reported in that table is concerned, that there is an inhibition or reduction, does it not report that?

A. I don't accept the interpretation.

Q. Well then, if even though it does report a significant difference, it is your position that it does not show inhibition, is that correct?

A. From the data given, it is too scanty to draw proper conclusions.

Q. Then, your answer is that the data reported in this table as to series 2 and 4 does not demonstrate a difference so as to show inhibition, is that correct?

A. That would be my interpretation, that the data is too scanty.

Q. Well, can't you answer that last question of mine yes or no?

A. I hesitate to answer it either way.

Q. In other words, you can't give me an answer yes or no?

A. The data is too scanty.

631 Q. Can't you just answer that one? Whether you can or not, you cannot give me an answer yes or no? Can you answer that one yes or no?

A. No.

Mr. Thiess: Your answer is "No"?

A. I cannot give you yes or no.

Q. And will you refer to the table and tell me whether or not there is not reported on the table no significant difference between series 3 and 5, both series having a second set of clover bacteria strains? Now, I am again asking you to take the data reported in the table and answer the question on that basis?

A. The variations again in 5 is so great that I would not give the answer yes.

Q. Then, your answer to my question is that there is no data in this table to show no significant difference between series 3 and 5, is that correct?

A. I would say that is correct, there is no significant difference.

Q. Well, in that answer do you mean to tell the Court that there is no significant difference between series 3 and 5, or that there is a significant difference, or that

632 they are the same?

A. The variation is so great that it is impossible for me to say that there is significant difference.

Q. How, you say that the variation is so great; that is what you meant?

A. Yes.

Q. Now, coming to the patents, prior art patents, you studied these patents and are thoroughly familiar with all of them, are you?

A. Quite familiar.

Q. And do you subscribe to the statements, scientific statements made in this first Earp-Thomas Patent No. 865,965?

633 The Witness: In part.

Mr. Thiess: Q. Well, to which ones do you not subscribe? Please enumerate them, each and all of them.

The Witness: His means of growing is on—

Mr. Thiess: Q. (Continuing) Would you just read to me from the patent the ones that you do not subscribe to, all of the ones that you don't subscribe to?

A. "The advantage of the solid medium"—

Q. Where are you reading now?

A. On page 3, column 2, line 42.

The Witness: Column 1, I mean.

(Continuing): "The advantage of the solid medium is that there is less danger of spilling the same in handling the vessels prior to sealing and hence less care is required in placing them in the incubator."

I do not subscribe to the artificial culture as a means of—

634 Mr. Thiess: Possibly I can shorten this. You say you have studied these patents and are familiar with them. Are there any other outstanding passages in this patent, which you ran across when you read it and studied it, outside of the one that you have just mentioned, that you can give me now, that you do not subscribe to?

A. Some of the means of fertilization—

Mr. Thiess: I mean pages in the patent.

The Witness: In this particular patent?

Mr. Thiess: In this particular patent?

A. That is the chief one that I object to, that is, I don't subscribe to—

Mr. Thiess: Yes.

The Witness: —is the solid medium, and then the advocation on top of that of a liquid medium.

Q. Well, that is the only page, wherever that is referred to in the patent, that is the only part of that patent, that you do not subscribe to?

A. The chief part.

635 Q. (Continuing) As expert in this art?

A. Chiefly.

Q. Is that correct?

A. Yes.

Q. Now, let us go to the second Earp-Thomas Patent, No. 1,099,121, and I want to ask you the same question with respect to that patent: Do you subscribe to all of the teachings contained in that patent, from the study that you made of that patent?

A. I object to the use of the term "soil" unless it covers several of the humus types.

It is dealing with ordinary field soils.

Q. Now, Dr. Manns, in reading this patent, didn't you mark it, in order to show any statements that were made in there that were not correct scientifically?

A. I did not mark them.

Q. Well, do you remember any in this patent that are not correct, that you can refer me to specifically, at the present time?

A. There are just differences of technique that I would employ in place of what is given in the patent.

Q. And you consider that technique not good technique—

636 A. It could be improved upon.

Q. —as referred to in the patent?

A. It could be improved upon.

Q. And you would prefer to use your technique?

A. I would prefer to use humus instead of soil, yes.

Q. And at the present time, based on the study that you made of this patent, you have no other outstanding statements in the patent which you consider are not good from a scientific standpoint, is that your position?

A. That is my position.

Q. (Continuing) As a man skilled in this art?

A. Yes.

Q. Did you say "Yes"?

A. I said "Yes".

Q. Now, let us take the next patent, which is the patent to Bottomley, No. 1,106,275. Now, this patent on its face is

directed, is it not, to a treatment of peat for manurial and other purposes?

A. That is correct.

Q. And isn't that the subject matter described and discussed in this patent?

A. Correct.

637 Q. And is there any teachings in this patent with respect to an inoculant?

A. Composite culture.

Q. Where do you find any teachings with respect to the composite culture?

A. (Reading):

"A product richer in nitrogen is obtained if nitrogen fixing organisms"—

I am reading from page 1, column 1, line 30:

"A product richer in nitrogen is obtained if nitrogen fixing organisms as *Azotobacter and Bacillus radicicola* are present in the mass."

Q. Now, that has been known for years, hasn't it, that those bacteria would be advantageous in the soil?

A. Yes.

Q. So that is something that was discovered years ago, in Germany, wasn't it?

A. Quite true.

Q. So that it isn't anything that is new in this patent?

A. That phase of it, no.

Q. All right. Now, let us take the next Earp-
638 Thomas patent, No. 1,252,332. Now, it is a fact, is it not, that this patent is directed primarily to a method of coating the culture, so as to protect it, is that correct?

A. Quite true.

Q. And do you subscribe to all of the statements scientifically made in this patent?

A. I do not.

Q. Well, will you point out in the patent those that you do not subscribe to, and I wish you would read from the patent?

A. Page 3, line 41, "It is desirable also to add a little powdered"—

Q. Page 3, was it?

A. Page 3, column 1.

Q. Line what?

A. 41; (Reading:) "It is desirable also to add a little

powdered boric acid or borax to the material during the drying."

Q. That is the only statement that you do not agree with there?

A. It is one of them?

Q. What?

639 A. It is one of the features I object to.

Q. Well, let us have the rest of them?

A. "The coating obtained"; on the same page, line 53.

Q. In the same column?

A. The same column. (Continuing): "The coating obtained by the use of agar-agar jelly in the manner described is particularly desirable in character."

Q. You don't agree with that?

A. I do not agree with that.

Q. Are there any others that you don't agree with?

A. That is the chief ones.

Q. You do not know of any others at the present time?

A. I think not.

Q. Now, we come to the Earp-Thomas patent No. 1,309,723, and I again wish to ask you whether you agree with the statements made, all of the statements made in this patent, as a result of your study thereof?

A. In part.

Q. Well, which ones do you not agree with?

A. The compost differs somewhat with that that I would consider the best.

640 Q. In what respect?

A. Several of the ingredients. He uses finely ground raw phosphate rock, which I do not believe during the composting would become very much available.

Q. And how would that affect the fertilizer?

A. It would affect the fertilizer; it would affect the compost as a valuable fertilizer.

Q. Now, are there any other statements in this patent that you don't agree with?

A. That is the chief one.

Q. You can't point out any at the present time, others?

The Witness: That is the chief one.

Mr. Thiess: Q. Now, coming to your patent, as I understand it, your patent discloses two products, is that correct?

A. Correct; correct.

Q. And what is the difference between the two products?

A. The one product mentioned, on page 1, line 44, "The first product, which I shall refer to herein as the bac-
641 terial compost, bacterizer or inoculator," that is the product which may be used as the inoculant for composting large amount of composts or for an inoculant on legume seed or soil.

Q. Now, with respect to this compost, reading on from the place where you have quoted, you say "is a rich compost containing all the known beneficial soil bacteria."

A. It originally applies to the flora.

Q. It applies to the flora?

A. Yes.

Q. But it applies to a rich compost, doesn't it, it is a rich compost?

A. "containing", it says.

Q. Yes, but it is a rich compost and it contains all the known beneficial soil bacteria?

A. That is correct.

Q. Then, that compost has a high nutrient value, does it not?

A. Not necessarily.

Q. Well, is that what you have described in your patent, or have you not, that it has a high nutrient value?

The Witness: It—

642 Mr. Thiess: Can't you answer that yes or no? Now, this is your own patent, Mr. Manns. Can't you answer that yes or no?

A. It applies to the compost for carrying these beneficial organisms.

Mr. Thiess: You haven't answered the question. Will you please read the question to him?

(Question read as follows:

"Q. Then, that compost has a high nutrient value, does it not?")

Now, can't you answer that yes or no?

A. I would say not necessarily.

Q. Now, what do you mean by "not necessarily"?

A. Rich compost, meaning that it has all the makeup, that is, not acid, not alkaline; it has the richness of a peat, high in nitrogen, but that nitrogen may not be available.

Q. Now, I am asking you whether in your patent, as you have described this, you have said and described this compost as one that has a high nutrient value? Now, will you answer that yes or no? Can't you do that right off? This is your patent, your alleged invention.

643 The Witness: High nutrient value you asked for?

Mr. Thiess: Yes.

Q. What would you say?

A. I would say no.

Q. Now, beginning on the last line of page 2, you say: "For introducing the legume bacteria"—

The Witness: Line, please?

Mr. Thiess: Q. The last line, column 1, page 2. Have you got it? "For introducing." Have you got it, Dr. Manns?

A. Column 1, did you say?

Q. Column 1, last line of the column.

A. Go ahead.

Q. (Reading:) "For introducing the legume bacteria I use a well inoculated soil upon which has grown the particular legume for which the inoculation is introduced."

Now, when you do this—

A. I haven't followed you now. Is that page 2?

Q. I beg your pardon. I will point it out to you. Page 2, right here, "for introducing".

A. Go ahead.

Mr. Thiess: Will you read it back, please?

644 (The record as above recorded was read by the reporter.)

Mr. Thiess: Q. Now, when you do this, how did you know what the efficiency of the different strains of the soil were that you used for this purpose? Did you or did you not know? You can answer that first.

A. In most cases I used cultures introduced into the soil.

Q. Well, I am referring to this statement in your patent right now where you use soil.

A. Correct.

Q. Well, how would you know? Did you know or didn't you know?

A. I did.

Q. How did you know?

A. Because the organisms were introduced into that inoculant.

Q. No, but you have used the soil which is full of bacteria?

A. Yes.

Q. How did you know what the efficiency of the bacteria in that soil was?

A. We have seen that grow the several different
645 legumes.

Q. You didn't know when you used this soil what its efficiency was, did you?

A. Absolutely.

Q. How?

A. By seeing the soil grown in this inoculant.

Q. Did you introduce the legumes I am talking about there. You say:

> "For introducing the legume bacteria I use a well inoculated soil upon which has grown the particular legume for which the inoculation is introduced."

Now, there were legume bacteria in that soil when you started, were there not?

A. Some.

Q. But you don't know how many or what their efficiency was?

A. No, not all of them. Those that were efficient I introduced by culture.

Q. Now, as I understand it, Dr. Manns, you were familiar with Earp-Thomas' work or patents at the time of the filing of your patent application, is that correct?

A. In part.

Q. Well, you knew of his patent. You said you had
646 been keeping abreast of the literature, did you not?

A. Correct.

Q. And you knew of his work, did you not?

A. Correct.

Q. Now, will you please explain in what respects you invented or claimed when you filed this application to have invented a composite culture different from that of the Earp-Thomas patents?

A. The carrier or base was improved.

Q. And that was your invention?

A. So far as the inoculant is concerned.

Mr. Thiess: That is all.
The Court: Anything further for the defendant?
Mr. Greer: No further examination of Dr. Manns.

647 LEWIS THOMPSON LEONARD, called as a witness on behalf of the defendant herein, being first duly sworn, was examined, and testified as follows:

Direct Examination by Mr. Greer.

Q. Will you please state your full name?
A. Lewis Thompson Leonard.
Q. Where do you live now, Doctor?
A. I live at RFD No. 3, Rockville, Maryland.
Q. Will you please state your training, education and experience in connection with leguminous inoculants, bacteriology and plant pathology?
A. I came into the Agricultural Department in 1904 and was associated with Dr. George T. Moore.
Q. Agricultural Department of the United States?
A. All my experience has been in the United States Department of Agriculture. And I was associated with Dr. George T. Moore in a minor capacity in 1904 and I have been continuing in that line of business, leguminous inoculants, ever since. I am not employed by the Department of Agriculture at the present time. I am retired.
Q. But your experience ran from 1904 to the date you retired?
A. 1904 to 1945.
Q. When?
648 A. January 1st, 1945.
Mr. Greer: Q. Will you state in that connection, Doctor, as to what particular branch of the Department of Agriculture your work was connected with?
A. This work was done— I worked in the Bureau of Plant Industry, the Bureau of Chemistry and Soils and the Bureau of Plant Industry, Soils and Agricultural Engineering. Those are merely changes in name. The work did not change.
Q. Did that have anything at all to do with inoculants for leguminous plants we have been talking about?

A. As I say, the work didn't change. It was inoculation of leguminous plants all through.

Q. What did you have to do with it?

A. In 1916 I was given charge of the inspection work which was an informal testing or informal collection and testing of samples of commercial leguminous inoculants found in stores, and so forth.

Q. And what was the character of that inspection? How was the inspection conducted?

A. It was conducted in the usual manner planting
649 inoculated and uninoculated seed. The seed inoculated with the sample sufficiently to give you something to work on and if the culture produced nodules and good growth and the check did not, the culture was considered satisfactory.

Q. Was there any of this—what do they call it?—the scientific analysis used as the test?

A. Well, we didn't use that. It didn't seem to—as a matter of fact, I don't use statistics at all, if you are referring to that.

Q. That is what I am referring to.

A. If I see and touch I can notice it without statistics, if I see everything before me.

Q. By a visual examination?

A. Yes, all of our work was largely a visual examination.

Q. Has the United States Department of Agriculture issued any official bulletins in that connection?

A. They issued two circulars on the results of our work. That is all that has been issued except one away back with which I had nothing to do.

Q. I will hand you a publication entitled, "Circular 703 of the Department of Agriculture", and ask you if you can identify this as being an official publication of the
650 Department of Agriculture (handing document to the witness)?

A. I can.

Mr. Greer: It is offered as Defendant's Exhibit 21.

(Said document entitled "Circular 703, Department of Agriculture", was marked Defendant's Exhibit 21 for identification.)

651 Mr. Greer: Q. Mr. Leonard, that circular sets

forth, does it not, a method of visual examination in the tests that the Department makes?

A. That is right.

Q. How long has that existed, that method of testing?

A. Well, this method is complete. This method hasn't been in operation for more than three years, but prior to that we used a slightly different method but produced the same results.

Q. Well, what was the difference with the visual examination.

A. It didn't have anything to do with the visual examination of the plant, no, no.

Q. You mean prior to the three years?

A. Considering the two methods we have used, one is automatically irrigated and the other is not.

Q. Well, my point was the method that was used three years ago.

A. The same method so far as examination and results were concerned.

Q. Now, in the discharge of your duties, Mr. Leonard, will you state whether or not you undertook to keep
652 posted with literature or any advance made in this art of inoculants for leguminous plants?

A. I maintained a card index file for official and abstracts of publications coming out on this subject. I don't claim to be entirely familiar with the field, all of the scientific articles.

Q. Well, what would you say, Mr. Leonard, as to whether or not in the year 1938 there was or was not generally believed that one specie of the bacteria for leguminous plants of this genus Rhizobium producing an inhibitory effect upon another species within the same culture whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented? What would be your statement as to whether or not that was a current belief among bacteriologists and those in this art in 1938?

653 A. I don't know. I never thought there was any inhibition.

The Court: Never mind what you thought.

Mr. Greer: It does not make any difference what your opinion was.

The Court: The answer is he doesn't know.

Mr. Greer: I don't think, may it please Your Honor, that the witness intended that.

Q. The question is do you know whether or not
654 there was a prevalent opinion among those skilled in this art as to inhibition?

A. No.

Q. Now, what can you say—

The Court: Well, in your previous answer, were you answering— did you think the question was whether there did exist such inhibitions?

The Witness: I evidently misunderstood.

The Court: I can see how you would. Your answer now is there was no such acceptance in the art.

The Witness: That is right, not among the people I knew.

Mr. Thiess: Now, I object to that answer.

The Court: That came pretty near making the answer bad, of course. I don't know what he is talking about.

The Witness: In my position I am associated with all these men that are in the business. My work put me in contact with all the men in the business.

The Court: In what business?

The Witness: In this leguminous inoculant business, the commercial business. I visited all the laboratories of the men.

The Court: Were they men skilled in the art?

655 The Witness: They ought to be men skilled in the art.

The Court: You accepted them as such.

The Witness: Yes.

Mr. Greer: Q. Mr. Leonard, what, if anything, can you tell us as to your knowledge of mixed cultures, commercial cultures, comprising a plurality of different strains of the bacteria Rhizobium in one culture, one base or
656 carrying means? What can you tell us, if anything, as to whether there have been such products on the market in the United States?

A. There have been such products on the market in the United States.

Q. Do you have in your possession any literature as to any particular one?

A. Not right now, no.

Q. I will hand you a pamphlet entitled, "Nitrogen from the Air Converted Into Food for Plants by Ferguson's Nitrogen Bacteria". What can you tell us as to your information as to that circular? Where did that come from? (Handing pamphlet to witness.)

A. That circular came from the file I made in the Department of Agriculture over a long period of years. I can't tell you exactly where it came from.

Q. How long has it been in the files of the Department?

A. It has been in the files probably since about 1918.

Q. Does it have any reference at all to a composite culture for inoculants?

A. It mentions "Ferguson's Nitrogen Bacteria, A Composite Culture".

Q. Do you know Dr. Ferguson?

657 A. I knew Dr. Ferguson personally.

Q. What can you say of whether, to your knowledge, Dr. Ferguson had any inoculant on the market in the United States prior to 1936?

A. I know he had this particular composite culture on the market.

Q. That is referred to in this circular?

A. That is right.

Mr. Greer: The defendant offers this circular in evidence as Defendant's Exhibit No. 22.

Mr. Thiess: If Your Honor please, we object to this circular, particularly from the standpoint that it is merely an advertisement that was passed out. It contains a number of testimonials from farmers. It is a puffing bulletin put out by a manufacturer and it is merely a self-serving statement made by this manufacturer at the time and there is no proof of its distribution.

The Court: Well, the least you can say for it is, I presume it shows there was offered for sale some 658 composite culture.

Mr. Thiess: I have no objection to having it offered for that purpose.

The Court: Isn't that the purpose?

Mr. Greer: Yes.

The Court: It says a composite culture on the outside, but I don't know what it is or what it is composed of.

Mr. Greer: The particular part we are relying upon is on the first page.

"A Composite Culture. One bottle available for all legumes."

And upon the back part are:

"Prices of Ferguson's Composite Culture Nitrogen-Fixing Bacteria. Available for Clovers, Alfalfa, Beans,

Peas, Vetches, Lupines, Soy Beans, and all other Legumes."

The particular portions in here that I expect to rely upon are pages 5 and 6 where a paragraph is devoted to the comparative efficiency of Ferguson's composite bacteria with other bacteria.

Mr. Thiess: We object to that in an advertisement of this kind, if Your Honor please. If they want to
659 make that sort of comparison or if they want to bring this Ferguson's composite culture into this picture, except as has been testified by this witness that he saw it and it was made, the man should come in and tell about it so he could be subject to cross-examination.

The Court: I didn't quite follow you on that last page. What was that?

Mr. Greer: (Reading:)

"Comparative Efficiency of Ferguson's Composite Bacteria With Other Bacteria."

We are merely relying upon it as the publication showing there was a composite culture.

The Court: Exhibit 22 is received in evidence for the limited purpose of showing there was something called a composite culture for legumes on the market prior to 1938.

Mr. Greer: Yes.

(Said pamphlet entitled "Nitrogen from the Air Converted Into Food for Plants By Ferguson's Nitrogen Bacteria" so offered was received in evidence by the Court and marked Defendant's Exhibit No. 22.)

660 Mr. Greer: Q. Mr. Bond, when on the stand, cited two articles by Lewis T. Leonard and W. R. Dodson, one of them, and the other some tests with Soil-Grow by Lewis T. Leonard.

I will hand you first the article on the effects of non-beneficial nodule bacteria on Austrian winter peas as reprinted from the Journal of Agricultural Research, and will ask you to look at the article and tell us the purpose of it, and whether or not there was any opinion expressed by you there as to the inhibition of a plurality of cultures as is set up in the Bond patent?

661 I would like to introduce it in evidence.

The Court: Have it marked Defendant's Exhibit 23. And it is conceded that that is the article Mr. Bond referred to without offering it, as you say, in evidence?

The Court: It may be received.

662 (Said article entitled "The Effects of Nonbeneficial Nodule Bacteria On Austrian Winter Pea", "By Lewis T. Leonard and W. R. Dodson", so offered, was received in evidence by the Court, and marked Defendant's Exhibit 23.)

Mr. Greer: Now, Mr. Leonard, will you please explain this to us?

A. The point in question involves a species of Rhizobium Leguminosarum.

663 Q. And this combination of organisms represent the combination of an inefficient species, or inefficient strain of this same species, with an efficient strain of this species; and what would be the effect of that mixture?

A. The effect would be that the inefficient strain would drag down the efficient strain in the ultimate result. I mean, the ultimate result would be the product of the two organisms working on the plant. Now, I think it is fair— I don't know whether you will object to this or not, but it seems to me that I should explain that in Mr. Bond's patent the organisms combined are of different species.

Q. Yes, sir.

A. These are the same species.

664 Mr. Greer: Q. I hand you now another paper purporting to have been written by Mr. Lewis T. Leonard, under the title "Some Tests with Soilgro". Are you the Lewis T. Leonard referred to there?

A. I am.

Q. You heard Mr. Bond's testimony in which he made reference to that article, did you?

A. I was here.

Mr. Greer: Well, I think, may it please your Honor, we will offer this in evidence as Defendant's Exhibit No. 24.

(Said Article, headed "Some Tests With Soilgro", by Mr. Lewis T. Leonard, so offered and admitted in evidence, was thereupon marked as Defendant's Exhibit 24.)

665 Q. Mr. Leonard, what was the purpose of that article?

A. That article involves fraudulent material, and I

think if I am permitted to read a paragraph in there it will indicate what it is.

(Article handed to the witness.)

This is the last paragraph on page 624, next to the last paragraph, the second sentence in the paragraph.

Mr. Thiess: Q. You say 624?

A. Page 624. (Reading)

"The packages contain two 1-gallon cans of similar rectangular shape, one green in color, holding the bacteria, the other brown, containing the 'bacteria food.'

"The liquid is light brown in color, smelling somewhat like a weak rain water solution of manure. In this respect, it resembles Nitrobacter Soil Vaccine which was recently on the market and which was found to be practically worthless. The bacterial food consists of sandy soil mixed with rotted manure, containing about 40% moisture. Plant stems and balls of manure covered with a white substance, presumably lime, were noticeable. The material is not homogeneous."

666 Q. Can you find in that article any reference to the doctrine of inhibition?

A. Nothing regarding inhibition.

Q. Have you examined the article referred to by Mr. Bond, a German article by Bredemann?

A. I have looked it over.

Q. Now, without offering this article in evidence, I just want to read the first paragraph and ask you if you are in accord with that, reading:

"N content (column 8) of the harvest is not influenced through the inoculation; in some cases there occur small increases in the percentual nitrogen content, and in other cases small decreases, but both of them irregularly, so that no conclusions can be drawn with respect to the influence of the inoculation."

Is that a correct translation from that article?

A. I don't know about that, but if it is a correct translation the author explained the material himself, or explained the condition himself.

Q. Have you examined the article by Paul Emer-
667 son, which was referred to by Mr. Bond in his testimony?

A. I have seen it a long time ago.

Q. Can you tell us whether or not there is anything

in that article that advocates the theory of inhibition between the various bacteria of the Rhizobium genus?

A. The only nodule bacteria mentioned here in the table 10, page 142, is that of soy beans, so there is no question of a combination of legume bacteria.

Q. Well, now, have you examined another article that was referred to by Mr. Bond, by Gerlach and Vogel, I believe it was, a German article?

A. I have seen it.

Q. What would you say from your examination of that article, Mr. Leonard, as to whether there is any acceptance of a theory or doctrine of inhibition in these inoculants?

A. The author in a paragraph in there states that he hasn't come to a definite conclusion and that he should do more work to find out whether what he did was correct.

Mr. Thiess: Q. That is with respect to inhibition?

A. Yes.

668 Mr. Greer: Q. From your examination, Mr. Leonard, could you tell us whether or not there are any differences in the functioning of bacteria of a mixed culture in a garden size over the functioning of bacteria in a field size inoculant?

A. I only have experience with the two comparisons in connection with peas. We generally test a pea crop all at the same time and that way the peas of garden culture are growing at the same time as the peas that are treated with the single culture, and I haven't noted any particular differences between the two.

Mr. Greer: You may take the witness.

Cross-Examination by Mr. Thiess.

Q. Mr. Leonard, did you make any search of the literature?

A. About what?

669 Q. To ascertain whether or not there was inhibition?

A. No.

Q. And did you make any tests to ascertain that proposition?

A. Not definite tests, no.

Q. Now, you have referred to this inspection that you gave these plants for the Government?

A. Yes.

Q. And you referred to it as an informal inspection.
A. Yes.
Q. Am I right in saying that you make this inspection for the Government because it would be too large a job to give these plants a real scientific inspection whereby you would make a nitrogen analysis in a chemical way?
A. Yes, it is too large a job for that. I mean—
Q. And isn't that the reason that you use this informal inspection?
A. That has nothing to do with it. The informal inspection refers to the fact that it is not a legal inspection or proposition. We don't prosecute anybody. If we find poor cultures we notify them of that fact and co-
670 operate with them in the matter of any mistakes or errors that might be in the culture.
Q. You would agree with me, would you not, that if you really wanted to know definitely whether there was a difference there of nitrogen fixation of between 10 to 30 per cent, you would have to make a chemical test?
A. Possibly so.
Q. What did you say?
A. Possibly so, but it is not done very much.
Q. Well, it is not done in the laboratories because it is too large a test to undertake by these experimental laboratories?
A. Yes. I run about 15,000—I used to run about 15,000 vegetation tests in one year, and if you ran a nitrogen analysis on all those you would be wasting all your time on nitrogen analyses.
Q. That is what I had in mind. Now, I would like to refer you to a paper entitled "A Simple Assembly for Use in the Testing of Cultures of Rhizobia", which I understand, according to this paper, was written by you. You are the author?
671 A. That is right.
Q. And it was published in Volume 45, No. 6, June 1943, of the Journal of Bacteriology, is that correct?
A. That is correct.
Q. And may I call your attention to page 521, where you are discussing sterilization, and you say, "The complete assemblies may now be placed in the sterilizers and subjected to steam under 15 pound pressure for one half hour." You consider that good sterilization, do you not?
A. Yes, sir, when it is pure sand and the soil wet.

Q. And if it isn't pure sand, to what extent would you have to increase that sterilization?

A. Well, if it were—you see, these are small jars, you understand, and the sand is wet and the steam penetrates. If the sand were not wet we would probably have to sterilize an hour, but the sand is practically sterile before we put it in there. It is not like a peat preparation where it is full of organisms, or a soil preparation.

Q. Well, a legume bacteria, if subjected to a temperature of what centigrade for a period of about 10 minutes, would be killed?

672 A. Well, that depends on in what condition they are. If they are in a liquid they would die quicker than if they were on seed, in a dry condition.

Q. Well, let us take both of them. First let us take the liquid condition.

A. About 50 degrees.

Q. Centigrade?

A. Centigrade.

Q. And for how long?

A. Oh, about 15 minutes.

Q. And if it was on a seed how long and what temperature?

A. About 70 degrees.

Q. Centigrade?

A. For three hours.

Q. Centigrade?

A. Yes.

Mr. Thiess: That is all.

Mr. Greer: May it please your Honor, there is one question I would like to ask Mr. Leonard that I really should have asked on direct and overlooked.

The Court: All right.

673 *Redirect Examination by Mr. Greer.*

Q. Have you made any investigation at all, Mr. Leonard, looking toward the question of whether there has been an increase or decrease of sales of inoculants in the country since 1937?

A. Well, I think there has been, and I conducted a survey in 1940 which indicated that fact.

Q. That there was a general increase in sales?

A. General increase, yes.

Q. Was that in any proportion at all or was it slight?
A. Why, it was probably a third more than earlier.
Mr. Greer: That is all.
(Witness excused.)
The Court: Call your next.
Mr. Greer: Dr. Hofer. I think, may it please your Honor, this will be my last witness.

ALVIN WILLIAM HOFER, a witness on behalf of the defendant herein, having been first duly sworn, testified as follows:

Direct Examination by Mr. Greer.

Q. Will you please state your name, age and residence?
674 A. Alvin William Hofer. My business address is New York State Agricultural Experiment Station, Geneva, New York. My age is forty-two.
Q. And what is your business?
A. I am engaged in the inspection of commercial legume inoculants, for the State of New York.
Q. I did not understand your answer to the first question. Did I understand that you were a bacteriologist?
A. I am a bacteriologist.
Q. And what is the inspection that you do in the State of New York?
A. The Inspectors for the State Department of Agriculture and Markets go out into the state where the farmers buy their cultures, and purchase samples for inspection. Those samples by law are delivered to the experiment station for inspection. That is my work.
Q. Would you tell us whether or not you keep up with the current literature and publications relating to inoculants of this character?
A. I do, and I would furthermore say that I do it almost religiously because we have a very good system
675 at the experiment station for bringing to our attention current articles.
Q. And how long has that been the case?
A. Ever since I have been there, I know.
Q. And how long have you been there?
A. Since July 1, 1931.

Q. Well, now, Doctor, I would read you from the Bond patent the statement appearing on page 2, the left-hand column, beginning at line 74.

"It was generally believed that one species—"

That is referring to the species of Rhizobium bacteria.

"It was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented."

What have you to say as to the accuracy and correctness of that statement?

A. Neither I nor any other scientist that I know engaged in this work, with the exception of Mr. Bond, 676 subscribes to that belief.

Mr. Thiess: I object to that answer, if your Honor please. He says "with the exception of Mr. Bond." He does not know all the scientists.

The Witness: I said all that I know in this field.

Mr. Thiess: He can say all that he knows but he can't say "all that I know with the exception of Mr. Bond." I understood it meant all the scientists under those circumstances.

The Witness: All that I know, that are working on the subject.

The Court: He said all that he knew.

Mr. Thiess: And you know Mr. Bond?

The Witness: Yes, sir.

Mr. Thiess: I see.

Mr. Greer: Q. I will ask you whether or not you have made any research or investigation among scientists for the purpose of determining whether or not there was such a belief?

A. Such a research was made a month or two ago, and these letters directed to the foremost men in this field showed that these men are unanimously of the 677 opinion that there is no such thing as this inhibition.

Q. Will you kindly give us the names of such scientists or men that you made this research with?

A. The first is Dr. Waksman. Dr. Waksman is an authority in this field of work of antibiotic effects of organisms against each other, and furthermore—

Mr. Thiess: If your Honor please—

The Court: The question merely asked the names and don't dissertate about their qualifications.

The Witness: Oh, excuse me. Dr. S. A. Waksman, New Jersey Experiment Station; A. G. Lockheed, Ontario Experimental Farms, Ottawa, Ontario; Dr. A. G. Norman, Iowa State College, Ames, Iowa. I have some more on the list there. I don't happen to have this list with me.

Mr. Neuman: Before he continues with his answer, I think it is entirely improper for him to testify that he contacted these men and what they told him.

The Court: I am not going to permit him to tell what these men told him. He has answered that this theory of inhibition was not accepted by so and so generally. Now, the question is—

Mr. Greer: What makes him say that.

678 The Court: Well, he is now answering that he consulted these men.

Mr. Greer: Yes, sir.

The Court: That is all I am going to permit him to say on that. I presume that is all he will ask, I don't know.

Mr. Greer: Well, I was next going to introduce the letters from the men, not for the purpose of what is contained in the letters themselves but in corroboration of his statement that he had made this investigation among scientists in this country.

The Court: Well, isn't that a matter for them to come before the Court, to appear and testify?

Mr. Greer: As to any facts in the letters, yes, sir. I am not offering the letters for proof of the facts in the letters but proof and corroboration of Dr. Hofer's statement that he had made this investigation among scientists in the country.

Mr. Thiess: If your Honor please, he has testified that he has interviewed these gentlemen, and I don't see any reason to encumber the record with these letters.

Mr. Greer: If it will not be disputed I will agree with you.

679 The Court: Well. I will let him finish his list of names, if he hasn't already.

The Witness: G. G. Pohlman, West Virginia; W. A. Albrecht, of the University of Columbia of Missouri.

Mr. Greer: Q. Anybody from Canada?

A. Yes, I have Dr. Lockheed. I think there were two or three more but I cannot recall them at the moment.

Mr. Greer: I would like, may it please your Honor, to offer these letters as Defendant's Exhibit 25.

The Court: Letters from these persons that were named by the witness?

Mr. Greer: Yes, sir.

The Court: Is that what they are?

Mr. Greer: Yes, sir. That will be 25, A, B, C, D, E, F, G, and H inclusive.

Mr. Neuman: We renew our objection to the offer.

The Court: The objection will be sustained.

Mr. Greer: I will have them marked.

(Said documents were marked as Defendant's Exhibits 25-A, 25-B, 25-C, 25-D, 25-E, 25-F and 25-H, for identification.)

680 Mr. Greer: Q. Now, Dr. Hofer, can you tell us whether or not you have conducted any tests on the question of this symbiotic relationship between various strains of bacteria?

A. Yes, I have.

Q. Where and when were those tests conducted?

A. Those tests were made in the greenhouses of the New York State Agricultural Experiment Station this past winter.

Q. Have you any report showing what those tests were?

A. Yes, I have.

They were begun the middle of September and concluded about the 20th of February. I think the exact date in September was the 17th, I am not absolutely certain as to that.

The Court: Last September?

The Witness: Yes.

Mr. Greer: Q. Will you relate to the Court as briefly as you can, Doctor, what these tests were and what
681 was the result of them? I don't mean the details; just give us a general summary of what the tests were.

A. The test was for the purpose of determining whether or not such inhibition actually does occur. To conduct the tests I wrote to Mr. Leonard, of the U. S. Department of Agriculture, simply asking him for five effective strains for sweet clover, red clover, and soy beans.

Q. Do they belong to different cross-inoculation groups?

A. Yes, they do. When these cultures arrived they

were used to make inoculants in which each of the cultures was grown as a single strain. At the same time inoculants were prepared on an agar surface, in which these fifteen strains of bacteria grew in intimate contact with each other, and they were allowed to remain there and grow in that way for a period of two weeks. At the end of that time the cultures, the bacteria, were removed by adding 100 c.c. of sterile water to each of these bottles. The culture was mixed thoroughly with the water and 1 c.c. of—two 1 c.c. portions of the material were put into each of the pots in the greenhouse. Because of
682 the fact that the arrival of the cultures had been delayed somewhat, and since it made no difference in the result, the soil was inoculated rather than the seed. This is a practice that has been followed in the past, and scientists agree that it has no effect upon the results.

The plants were grown and I can give you the details of that, if necessary, but an auto-irrigator system was used. The purpose of this was to keep the moisture at the optimum point for growth of the plants. The result was that where the plants had complete nutrition they grew vigorously. Of course, there was no nitrogen added to any of the pots. The soil was low in nitrogen to start with. The appearance of the controls confirmed this, because they made barely any growth. After being kept in the greenhouse until about February 20th, these plants were removed, washed very carefully to remove all the sand from the roots, they were dried and weighed and analyzed for nitrogen. The series that was run through completely from end to end was a series of red clover plants.

683 Q. Now, did you take any photographs of those plants while these tests were going on?

A. Yes, I did.

Q. I will hand you a set of three photographs and ask you to explain what each one of those are.

684 Mr. Greer: I will have the first one marked for identification as Defendant's Exhibit 26.

(The photograph was marked Defendant's Exhibit 26, being a picture of rows of pots, the front row of same bearing the following numbers on individual pots: 3, 4, 2, 0, 1-5, 5, 1, 5, 4, 1-5, 0, 3, 2, and 1.)

Mr. Greer: I will have the next one marked for identification as Defendant's Exhibit 27, showing the numbers on front of the pots as follows: 1, 1-5, 0, 3 and 2.

(The photograph showing pots with plants in same and showing the following numbers in front of the pots: 1, 1-5, 0, 3 and 2 was marked Defendant's Exhibit 27 for identification.)

Mr. Greer: And the remaining one I will have marked as Defendant's Exhibit 28.

(The photograph showing pots with plants therein was marked Defendant's Exhibit 28 for identification.)

Q. (By Mr. Greer) Explain what Defendant's Exhibit 26 is.

A. Now the large picture was taken by the com-
685 mercial photographer. This represents an experiment in which two kinds of plants were grown. The left half of the table, to the left of that left-hand flask, are sweet clover plants.

On the right are red clover plants and this is how they appeared on December 11, 1944.

Unfortunately due to light conditions the center area appears lighter than the rest but this is not significant because the plants appeared uniformly green with the exception of the two series marked "O", which had no inoculation.

The cultures from Mr. Leonard had simply been marked 1, 2, 3, 4 and 5, and the pots containing the 15 cultures, the composite cultures, are simply marked as 1 to 5. They should be really marked as 1 to 15.

Q. Well, what was in the middle? You said what was on the left and on the right but what was in the middle?

A. There is a vacant space in the middle just above that left-hand flask of water. That is the line between the sweet clover and the red clover plants.

686 Q. Well, now, what does Defendant's Exhibit marked for identification 27 show?

A. Now, which is that,—the one with the numbers?

Q. That is the one with the little "B" on it.

A. This picture was taken the first week in January of the red clover series. It is a rather close-up view of it and gives the details of the growth.

As you can see, the row marked "O" consisting of 8 pots made very poor growth. The other rows appear practically the same.

Q. And what were they inoculated with?

A. These were inoculated with red clover, single strains, with the exception of the control which had not, and the composite culture marked 1 to 5, which had inoculation from the composite culture made from the 15 strains from 3 different groups.

Q. 15 strains from 3 different groups?

A. That is right.

Q. And alfalfa in the group?

A. The alfalfa group was represented by cultures for sweet clover.

Q. Now what does Defendant's Exhibit for identification 28 show?

687 A. That represents simply another picture of these same red clover plants that have just been discussed.

Mr. Greer: Now, may it please your Honor, we would like to introduce these photographs in evidence as Defendant's Exhibits 26, 27 and 28, respectively.

The Court: They may be received.

(The photograph showing rows of pots, the front row of which bears the following numbers on the individual pots: "3, 4, 2, 0, 1-5, 5, 1, 5, 4, 1-5, 0, 3, 2 and 1" was received in evidence as Defendant's Exhibit 26.)

(The photograph showing pots with plants in same and having the following numbers in front of the pots: "1, 1-5, 0, 3 and 2" was received in evidence as Defendant's Exhibit 27.)

(The photograph showing close-up view of plants in pots, was received in evidence as Defendant's Exhibit 28.)

688 Q. (By Mr. Greer) Now, did I understand you to state that you had made a chemical analysis after the harvesting of these plants, to determine the question of nitrogen fixation?

A. That is correct.

Q. And have you a report showing what that analysis shows?

A. Yes.

Q. Will you briefly explain that to the court?

A. This table consists of—

Mr. Greer: We will ask that the table referred to by the witness be marked for identification as Defendant's Exhibit 29.

(The table bearing the heading: CLOVER PLANTS—WEIGHTS EXPRESSED IN GRAMS, and with columns a, b, c, d, e, f, g and h on the left-hand side of table and the columns: Total, Average % N, Total N% 8 Pots, and Total on the right-hand side of table, was marked Defendant's Exhibit 29 for identification.)

689 Q. (By Mr. Greer) Explain that.

A. The left half of that Table represents the weights in grams, the dry weights in grams of these clover plants.

Starting with the figure 1, Tops and reading from left to right, we get the weights of the tops, the dry weights of the tops of the clover plants grown in each of those pots. In the next row down are 1, Roots and we get—

The Court: Wait a minute. Let us see that first line. Which pot has those which were not inoculated?

The Witness: They are at the very bottom, marked "O".

The Court: Well, what is the a, b, c, d, e, f, g and h?

The Witness: That simply refers to the different pots.

The Court: Different pots of the same series?

The Witness: That is right.

A. (continued) The second row, marked 1, Roots, refers to the same thing for the roots,—the dry weight of the roots in each of these individual pots.

The next row down, marked 1, Total, consists of the items in each case, for each pot of the above two figures.

It is the total dry weight of plant material per pot.

690 Number 2 is the same thing for that series; and likewise for 3, 4 and 5.

The same thing is true for the one marked 1-15, which contain 15 strains from three different groups. The one marked "O", that is, O, Tops, was, as in the experiment by Mr. Curie, so deficient in top growth that there was practically nothing there and for that reason the roots and tops were weighed together.

No; excuse me; they were not either. But, as you can see, the tops were very deficient in growth. That arrangement follows the arrangement above.

On the right-hand half of this Table, the first figure under Total, gives the total weight of tops of plants inoculated with Strain 1.

The second figure down gives the total weight of roots.

In the next column, to the right, the top figures gives

the average weight of tops. The next figure down, the average weight of roots, and the third figure the total of these two figures.

And likewise on down the table for all of the different series. The third column, marked: Percent Nitrogen, contains the results of the nitrogen analyses. The tops in this instance contained 3.22% nitrogen. The roots con-
691 tained 2.47% nitrogen, and so on down, till we get to the one marked O, and here is where the roots and the tops were combined, because the amount of top material was so very scanty.

The next column, marked: Total Nitrogen Percent, 8 Pots, is arrived at by multiplying the proportion of nitrogen by the weight, the total weight of plants in that series.

The total amount of nitrogen in the 8 pots—the total amount of nitrogen in the tops from the 8 pots marked inoculated with one culture, Culture 1, was 3.35 grams.

In the roots of that same series the amount of nitrogen was 1.77 grams, giving a total weight of nitrogen present in those plants of 5.12 grams.

If we may go to the last column on the right, we will see that the total amount of nitrogen fixed by Culture 1 was 5.12 grams.

In the 8 pots of Culture 2 there were 4.92 grams of nitrogen.

The plants in Series 3 contained 5.35 grams of nitrogen.

In Series 4 the plants contained 5.25 grams of nitrogen.

In Series 5 the plants contained 5.56 grams of nitrogen, and in the composite culture in which the bacteria
692 had been living intimately for a period of two weeks the total amount of nitrogen fixed by the red clover was 5.89 grams. The row of pots containing—

The Court: You said the total amount of nitrogen fixed by red clover bacteria. There were a lot of different bacteria there besides red clover, weren't there?

The Witness: We do not know whether they fixed nitrogen or not. We assumed that they did not.

The Court: That is the composite group?

The Witness: That is correct.

The Court: When you say it is fixed by the red clover, that is just an assumption that you make, is it?

The Witness: Yes, as you suggest there is, of course—

The Court: You think the other bacteria remained dormant, do you, and have no effect on the red clover?

The Witness: We have felt that way. Now, we have no way of being sure that the alfalfa bacteria might not have helped in some way, or the soybean bacteria. That is an open question.

The Court: All right.

A. (continued) The total amount of nitrogen, if on the basis of 8 pots, present in the control series was 0.218 grams.

693 As you can see, the method was very favorable for nitrogen fixation and the cultures all fixed rather large amounts.

Q. (By Mr. Greer) What was your conclusion from this test as to beneficial or deleterious effect, in the use of a mixed culture?

A. My conclusion is that if there is an effect upon the clover bacteria of having these other cultures present, that effect is beneficial.

Mr. Greer: Now, defendant offers in evidence this page of figures as to the test testified to by the witness, as Defendant's Exhibit 29.

The Court: It may be received.

(The table bearing the heading: Clover Plants—Weights Expressed in Grams, with columns a, b, c, d, e, f, g and h on left-hand side and columns: Total, Average, % N, Total N% 8 Pots, and Total on right-hand side, was received in evidence as Defendant's Exhibit 29.)

694 Q. (By Mr. Greer) Did you have any experience or do you know anything at all about garden sized mixtured cultures of these bacteria for leguminous plants?

A. These garden mixtures have been coming in among the samples sent us by the inspectors for quite a number of years. I think, in fact, the first one came in 1931.

I have made a record of some of those, beginning with the year 1933, I believe.

Q. A record of what, in connection with them?

A. The number of the cultures among those garden samples which were incapable of forming nodules on the plants, and compared that with the number of non-garden cultures, to see whether they were any better or any worse in their ability to form nodules on the roots of the plants

for which they were intended.

Q. Is that the report you have reference to (handing paper to the witness)?

A. Yes.

Mr. Thiess: Now, if your Honor please, I would like to ask the witness what he made this report from. What was your data?

695 The Witness: This report was made from the officially published report.

Mr. Greer: Again that is cross-examination.

Mr. Thiess: It is cross-examination with respect to this exhibit.

The Court: It bears on the competence of the exhibit, I think. I will let you ask him that.

Mr. Greer: All right; I am perfectly willing to let it go in.

A. (continued) This was made from the officially published reports by the State of New York, first through the State Department of Agriculture and Markets, at Albany, and in the last few years, beginning in 1940, I believe, or 1941, through a publication called: Farm Research, which is put out by the Experiment Station. I have copies of those back there where I was sitting.

Mr. Thiess: Now, if your Honor please, he is compiling a report here from the reports compiled by others. There is no way of investigating the accuracy or the veracity of these figures, the conclusiveness of the figures.

The Court: I don't know yet what kind of a report this is.

Mr. Greer: I think if your Honor would let me
696 examine the witness and identify it without interruption, that probably we could get at this with less consumption of time.

Q. (By Mr. Greer) Who prepared this report?

A. I personally conducted all these tests and prepared each of the individual reports to the state authorities upon which this particular summary is based.

Q. And for whom was the report prepared?

A. It was prepared for the State of New York.

Q. And was done by you?

A. That is right.

Mr. Greer: I think that is sufficient.

The Court: It is a test for what, and a report of a test for what?

The Witness: The test is to show whether the particular bacteria said to be in these inoculants are actually there. An alfalfa inoculant, for instance, says: Good for the inoculation of alfalfa plants. And my test was to determine and see whether that culture did contain the bacteria which were supposed to be there.

Q. (By Mr. Greer) Were these the garden sized cultures you were talking about?

A. Both types.

The Court: The garden sized and the field size?

697 The Witness: And the field size.

The Court: Were they all single cultures?

The Witness: The garden sized consist of mixed cultures. It may contain from three to five groups of bacteria.

The Court: This is a test to determine whether the product that you tested had the things in it that it was advertised to have?

The Witness: That is right.

The Court: That is what the State of New York was interested in, whether the public was being defrauded in any way?

The Witness: Yes, to see whether really a genuinely favorable, a viable, a lively, active bacteria was present.

Q. (By Mr. Greer) And whether that functioned or not? Would that enter into it?

A. That is right.

Mr. Greer: That is the point, whether the product was satisfactory or unsatisfactory.

The Court: In this case you are in that respect only concerned with the composite group, aren't you?

Mr. Greer: No, sir; the composite group, yes. We are not interested in the single group at all. In this report

698 he happened to have, as I understand it,—like most of these statisticians,—they make it as confusing as possible, but as I understand it, they have a column of one-plant group, and they have another column of the garden mixed culture. We are not interested in the single group, as far as that is concerned.

700 Q. Dr. Hofer, when you commenced your testimony, I neglected to ask you the usual questions.

Mr. Greer: Q. I neglected to ask you the usual questions as to your qualifications in this field concerning which we are conducting this inquiry. Will you please tell us

what has been your education, training and experience in the art of bacteriology and plant pathology?

A. I was at the University of Illinois, in the College of Agriculture, from 1925 to 1929.

From 1926 to 1929, I was employed in the Division of Soil Biology. It was a very menial task, cleaning glassware and preparing media, but, nevertheless—

Q. Of what state?

A. Illinois. But, nevertheless, heard discussions and participated in discussions concerning soil bacteria.

From there I went to the University of Wisconsin
701 and studied one year under Dr. E. B. Fred, who is now the President of the University, received my Master's Degree in the summer of 1930, and my Bachelor's Degree was received from the University of Illinois.

The second year, I studied under Dr. I. L. Baldwin, who is now the Dean of the Graduate School of the University of Wisconsin.

On July 1st, 1931, I took my present position and while there spent vacations and, under special arrangements, completed the work for my Doctor's Degree at Cornell University. This work was completed in 1937 and was done under the direction of Dr. H. J. Conn, who has been long known in the field of soil bacteriology, and Dr. J. K. Wilson.

Dr. Conn was a part of a 2-man committee who supervised my work at Geneva and Dr. Wilson had charge of that that I did at Cornell. They worked together on the committee.

Q. Just exactly what is your present position?

A. My title is Assistant Professor of Cornell University, because the New York State Agricultural Experiment Station is administered by Cornell University.

Q. All right. Now, Doctor, coming back to this report which I would like to have marked for identification
702 as Defendant's Exhibit No. 30.

(Said report headed "Comparison of Types of Culture Based Upon Tests Made in New York State" was thereupon marked as Defendant's Exhibit No. 30, for identification.)

Now, will you please explain what that report consists of?

A. As stated previously, each year reports are con-

ducted for the State of New York. These are those reports. And from each of these reports, I have taken four figures.

Take for 1933, the total number of cultures for one plant group that were tested was 51.

Q. Does that mean a single strain of bacteria?

A. That is right.

Mr. Greer: Yes.

The Witness: The number of those 51 that were unsatisfactory was 7.

The number of garden cultures that were tested in 1933 was 7.

Mr. Greer: Q. Now, what do you mean by garden culture? A mixed culture or single?

A. A small package that are made for inoculation
703 of peas, beans and Lupines, or peas, beans and lima beans as they were in those days.

Q. Those are cross-inoculation groups?

A. That is right.

Mr. Greer: All right. Go ahead.

The Witness: Now, for each year I have taken out the pertinent figures, in that fashion. I should like to call your attention to the fact that in 1933, '4 and '5, there were a great number of unsatisfactory cultures. The techniques of manufacture had not been well perfected in those days and we found a lot of unsatisfactory cultures among those inspected.

Now, with the exception of two garden cultures in 1937, from one company, the record of the garden culture has been very satisfactory as far back as 1935, with that one single exception.

Mr. Greer: The defendant offers in evidence this report that has been identified by the witness, as Defendant's Exhibit No. 30.

The Court: It may be received.

(Said report headed "Comparison of Types of Cul-
704 tures Based Upon Tests Made in New York State", so offered and received in evidence, was marked as Defendant's Exhibit No. 30.)

Mr. Greer: Q. Going back for a moment, to Defendant's Exhibit 29, which was a report of the results of your tests as to a single culture, as I understand it, and a composite culture, am I correct in my understanding that you used 8 pots in each series?

A. That is right.

Q. (Continuing) In connection with this test?

A. That is right.

Q. Will you please explain to the Court why you used as many as eight pots in each series?

A. I have previously stated that there was nothing in scientific literature or opinion, up to the year 1938, to indicate that there was such a thing as inhibition. Later, the question came up, of course, and in order to avoid errors in an experiment of this kind, it seemed desirable to use that many pots.

Now, plants do not grow uniformly. Each plant is a law in itself, and no matter how a person conducts an experiment like this, there will be a variation from pot to pot, it cannot be avoided. If too few pots are taken, one series may be a little higher than the other and a misleading conclusion drawn. Therefore, it is wise to have quite a number of pots, so that that average will be just about as accurate as it is possible to get it. Now, this has a further advantage, and that is that the formulas used in statistical analyses are so devised that the more pots that are run, the smaller becomes this plus and minus. In other words, the formulas recognize that the more pots that are run, the more accurate the answer; and for that reason, the experiment to be sound, and the matter of statistical analysis was paid no attention to in the end because the experiment was set up soundly from that standpoint.

Q. What would be your opinion, as a scientist, as to the advantages or effective results of a comparison between two series of just where one was 3 and the other was 5, would that have any effect one way or another on it?

A. It would not be a fair test, and furthermore, with only 3 pots, if the test had been repeated, it might have given exactly the opposite result.

Q. Have you ever conducted any tests of the garden types of culture that were on the United States market, in comparison with a test of a single strain of the bacteria that was in the garden culture strain, to determine what effect, if any, was produced by the mixture?

A. You mean as far as nodule production was concerned, or otherwise? I did not get that?

Q. Nitrogen fixation?

A. Nitrogen fixation?

Q. Yes.

A. I have.

Q. I hand you a document, and I will ask you to state what it is, first? Please take this one, that you can keep, as a copy.

A. This is a small report which may sometime be presented for publication. I have not made up my mind, but, it is written in the form of a paper showing the results of comparisons between single strains and mixed cultures for lima beans.

Q. Now, what kind of mixed cultures were used in this test?

A. These were the small garden packages.

Q. And could you give us the names, the trade names of the garden packages that were used?

707 A. These cultures included single strains and mixed strains from the brands Nitragin and Nodogen.

Q. Any other?

A. There was one Legume-Aid, and possibly two more here.

Q. And how did you obtain those garden size mixtures?

A. Those samples were brought to me by the inspectors of the State Department of Agriculture for the routine tests and we are trying to extend those tests so that they will not measure only whether the proper bacteria are present in the culture, but also whether they are going to do what they are supposed to do in the field.

Q. As I understand you, then, these were routine tests that you made in your public capacity?

A. Yes, in the field.

Mr. Greer: I would like to have this report marked for identification as Defendant's Exhibit No. 31.

(Said report headed "Yield of Lima Beans From Two Types of Inoculants" was thereupon marked as Defendant's Exhibit No. 31 for identification.)

Q. Now, will you tell us, Doctor, what was the result of those tests in the comparison as to this question of nitrogen fixation, I mean the comparison between the garden mixtures and the single strain inoculation?

708 A. It should be stated, first, that in any nitrogen fixation experiment, there should be some better

growth by the inoculated plants. If the inoculated plants make no better growth than the uninoculated plants, there is no nitrogen fixation and the experiment is worthless.

In this test, there are sufficient differences between the uninoculated and the inoculated, especially in 1941, that there is little question but what an appreciable quantity of nitrogen was fixed. These plants were planted in rows one yard long each, and were scattered through a plot in accordance with the advice given by statisticians. When the beans matured, they were harvested, picking those in which the pods were full of beans and the quantity for each row was weighed green. The rows were not identified. They were simply picked and identified by their position in the field.

A week or so later, when some more had filled out, another picking was made, and I know, perhaps three pickings were made during the season. That is the way the housewife does it, and for garden use this would be a perfectly logical method.

The test yields as given there in the 1941 figures listed under Average show that there was 968 grams per row 709 in the uninoculated series.

The single cultures produced 1637 and 1397—I think I have the averages here—1517 grams, the average for the single cultures.

The mixed cultures produced 2293 for the average of one field and 1556 for the average of the other, for a total of 1929.

Now, in 1942, the differences were not so great and yet, nitrogen fixation did occur as shown by the fact that there were increases, in fact, every treatment with bacteria increased the yield of lima beans.

Adding up the 2 figures for single cultures, 1892 and 2000, the average for single cultures is 1946.

For the mixed culture test, three figures, 2730, 2335 and 1919, or an average of 2328 per row.

Mr. Greer: All right.

Q. What was the final conclusion that you arrived at from these tests?

A. The final conclusion was similar to the conclusion of the experiment mentioned previously today, that if the various groups of nodule bacteria packed together in one

container had any effect on each other in these in-
710 stances, that would appear to have been favorable.

Mr. Greer: Now, the defendant offers this report as Defendant's Exhibit No. 31.

The Court: It may be received.

(Said report headed "Yield of Lima Beans From Two Types of Inoculants" was received in evidence by the Court as Defendant's Exhibit No. 31.)

The Court: Q. What do you take from the fact that in the third row—

The Witness: Let me see that copy.

The Court: Q. (Continuing)—at least two of them, mixed findings in 1942, were less than the uninoculated row?

A. Well, if a series of uninoculated plants were planted—

The Court: Q. And that is true also of the single lima bean inoculation in one instance?

A. Those always vary, just as any plants vary. That adds confusion to any experiment, so that one simply has to have enough plants to be sure, before he can be sure that he has a conclusion. There were 50 plants in each of these rows of one rod each.

The Court: Q. Well, it is apparent at least in the third row, that the uninoculated did better than either the single or the mixed inoculation, didn't it?

711 A. It did, in that comparison.

Mr. Greer: Q. Well, does that show that in some instances there is no effect or no inoculation at all?

A. That is why we have to use a number of repetitions of these things, before we can approach an accurate estimation, because any of these, if always taken singly, would give a terribly imperfect.

Q. In other words, does a man really know what brings about this nitrogen fixation or not?

A. No.

The Witness: In the field, on what appears to be perfectly level ground, there will be places where water stands, perhaps in a wet season. It would not be apparent at all in a dry season. There will be places where perhaps there is a little better drainage or maybe a dead furrow where the plow has separated the soil and it is a little lower or something, there are all kinds of these things, and it was because of these things that
712 the statistical analysis was developed. Many of these instances we cannot detect and in addition, we have

the hazard that even these individual plants begin growing and a plot will tend to start off according to their own way and there is nothing we can do about it.

The Court: Q. You don't have a failure in the pot test like you would in a field test, do you?

A. I don't know— They vary considerably, but looking at this data that is given, from pot to pot, there is really very great variation.

The Court: Q. Can you tell me, were the nodules present in this row 3 mixed, which has only 1575 grams?

A. In the greenhouse test, nodules were present.

Q. I am asking about this test here?

A. I could not dig up the plant without spoiling the test.

Mr. Greer: Q. I hand you another publication, Dr. Hofer, and ask you to state what that publication is?

A. This is Agricultural Bulletin 292 published by the Department of Agriculture and Markets of the State of New York.

Q. I will ask you to turn to pages 68 to 72 in that publication and tell me who prepared the report pub-
713 lished there?

A. I prepared that report.

Q. What does that report deal with?

A. That is one of the annual reports of the tests.

Q. Beginning on page 68, I mean, what particularly is the subject of it?

A. The heading is LEGUME INOCULANT TESTS FOR 1934.

Mr. Greer: The defendant would now like to offer this report in evidence as Defendant's Exhibit No. 32. I have given the other side a photostatic copy of pages 68 to 72 which I expect to rely upon.

Mr. Thiess: For what purpose is it being relied on?

Mr. Greer: In the first place, to show the method of tests that are adopted in the New York State Department as shown beginning on page 68 and the tests which had been conducted as to the brand of inoculant, the group that it was supposed to cover.

Mr. Thiess: You mean all of these various brands here?

Mr. Greer: Well, if you want to confine it to Nodogen which has been mentioned and Nitragin and Stimugerm, what they show for garden mixtures, is what I am talking
about, and the tests of the garden mixtures of culture
714 covering peas, beans, lima beans, and so forth.

Mr. Neuman: Well, isn't that exhibit, then a

duplication of your summary appearing on DX 30 which shows the tests made in 1934 of garden mixtures?

Mr. Greer: '34—

Mr. Neuman: 1934, you have included that year in your summary.

Mr. Greer: That would show in there, yes, as to those particular tests, but it does not show the method that was used.

Mr. Thiess: Are you limiting it, then, to the methods?

Mr. Greer: To the methods and tests that are shown there, as to the garden mixture cultures, as shown on pages 68 to 72.

The Court: It being so limited, it may be received.

Mr. Thiess: All right.

(Said AGRICULTURAL BULLETIN 292 of November, 1934, Published monthly by the Department of Agriculture and markets of the State of New York, entitled "Report of Analyses of Samples of Seed Collected in New York State July 1, 1933, to June 30, 1934 Also Report on Legume Inoculant Tests Made in 1934 (Pages 68 to 72 inclusive)" was received in
715 evidence, as aforesaid, and marked as Defendant's Exhibit No. 32.)

Mr. Greer: Q. Dr. Hofer, Mr. Bond was asked on his direct examination as to certain publications which he cited as support of belief in a doctrine of inhibition in this art between different species of Rhizobium bacteria, and one of those articles is one which was purported to have been written by H. J. Conn and A. W. Hofer. Are you the A. W. Hofer referred to in that article?

A. I am.

Q. Are you familiar with that article?

A. Yes.

Q. Will you please state to us what the article dealt with?

A. After sending a report such as which was just submitted as evidence—

The Court: He asked you what the article dealt with.

A. That is what I am describing. After submitting that report, those same data were used for a popular summarization to be sent to farmers, to explain to them the results of the tests.

Mr. Greer: Q. Then, Doctor, please state whether or

not there is anything in this article dealing with the
716 problem of inhibition or non-inhibition of cross-strains of Rhizobia bacteria?

A. There is nothing that could be so used.

The Court: Are you introducing that?

Mr. Greer: No. They didn't introduce it. He just simply referred to it, as supporting it, and I was contradicting them by the author himself.

The Court: Well, gentlemen—

Mr. Rathburn: That was not put in to show inhibition. That was put in to show that mixed cultures were unsatisfactory, that article.

The Court: Yes. Mr. Bond says that that was one of the teachings that said that there was inhibition in these strains.

Mr. Greer: That was the reason I was trying to contradict him.

Mr. Rathburn: Mr. Bond has said that this article was one from which he concluded that mixture cultures were unsatisfactory. It was not the specific article that taught him the inhibition feature.

The Court: Maybe I am not speaking of the right one. This is the one that taught him that mixed cultures
717 were unsatisfactory.

Mr. Greer: If they mean that they were unsatisfactory due to inhibition, then, that is competent to contradict, if they are stipulating.

The Court: Now, this witness has said that there is nothing in this article that teaches the doctrine of inhibition. Isn't that about what he said?

Mr. Greer: Yes, that is my understanding of it.

The Court: Well, how am I to determine which one of these witnesses is to be believed in connection with this situation? They each put an interpretation upon it and, without it being put in evidence, how am I going to pass on it?

Mr. Greer: We will be pleased to put it in evidence.

The Witness: I should be pleased to explain, if I may be allowed—

The Court: No. You have already explained with reference to your idea about it, and I know Bond's idea about it, but, here is a clash of views. One witness says one thing and the other witness another.

Mr. Thiess: Well, we will put it in evidence.

The Court: It may be one of the things on which this

case turns, and I don't know about it unless it is
718 put in evidence. It speaks for itself.

Mr. Greer: The defendant will offer it in evidence as Defendant's Exhibit 33.

The Court: That is, the article.

Mr. Greer: Will you mark it. That is the article by H. J. Conn and A. W. Hofer.

The Court: All right. It may be received.

(Said article designated as CIRCULAR No. 137 (Revised) New York State Agricultural Experiment Station, Geneva, N. Y., SOIL INOCULANT SERVICE, by H. J. CONN and A. W. HOFER, dated January 1, 1934, so offered and received in evidence, was marked as Defendant's Exhibit No. 33.)

719 Mr. Greer: Q. Will you read the portion underscored in that article?

A. (Reading:)

"This last year the poor products were often found to be mixed cultures sold in small containers, recommended for garden purposes. Those intended for"—

And there the underlining stops.

The Court: Let me have the exhibit.

720 The Court: (Reading:)

"This last year the poor products were often found to be mixed cultures sold in small containers, recommended for garden purposes. Those intended for the inoculation of soy beans were also of low quality. Further tests are necessary to determine the seriousness of the situation and to learn what measures should be taken to correct it."

Seriousness of what situation, Mr. Hofer?

The Witness: Defects in manufacturing technique that resulted in poor soy bean cultures and in this one out of the fourteen are poor garden cultures.

Mr. Greer: The underscoring in there is as it was received by us from counsel for the plaintiff.

Mr. Rathburn: That was Mr. Bond's underscoring put on there for the purpose of helping him when he was testifying.

The Court: All right.

Mr. Greer: Q. Now, will you state whether or not that had anything to do with the question of inhibi-
721 tion between the two strains?

A. No, it wasn't so intended.

Q. What was it that led you to the report of unsatisfactory conditions as to mixed cultures?

A. Because the cultures did not contain the bacteria that the container said they did have in them.

Mr. Greer: I see. Now, there are some other articles Mr. Bond referred to that have not been introduced in evidence. I don't know how to treat those.

The Court: Have you introduced any oral testimony concerning them?

Mr. Greer: Not yet.

The Court: I am only concerned— I am concerned particularly about them only if there is some other oral testimony which contravenes what he said.

Mr. Greer: My oral testimony would be in strict conflict with what Mr. Bond said about them. They have not been introduced in evidence. I will meet Mr. Bond's statement with my witness.

Q. Have you examined the articles referred to by Mr. Bond in his examination as emanating from Mr. A. G. Lochhead of the Division of Bacteriology of Canada?

A. I have.

722 Q. Did you find anything in that article dealing with the question of inhibition of different strains of the bacteria Rhizobium?

A. Before answering let me separate those into two groups. The first two articles dealt with cultures that were intended for the inoculation of non-legumes plus legumes. And Lochhead makes the statement that these mixtures— I can't quote it exactly, but the sense is that these mixtures are not good and should not be used. Bacteria only should be put into those cultures.

The second two state something more or less concerning the possibility of a culture being suppressed when in combination with other cultures, but he has conducted no tests in which he has used the same cultures as single strains using the same single strains both in the single culture and the mixed culture.

Mr. Thiess: If Your Honor please, I want to inject a question here, if I may. I want to know on what this witness bases his statement that he made no tests from that article.

The Witness: I made tests, but he did not make tests, as my test was reported earlier today, using the same cultures singly and in combination.

723 The Court: Are you telling us what the article discloses?

The Witness: No.

Mr. Greer: Confine yourself to what the article discloses.

Mr. Thiess: I move to strike it.

The Court: Unless it is disclosed in the article about the test, of course, that would be incompetent and will be stricken.

The Witness: The last two of those reports.

Mr. Greer: The question is whether there is anything in those articles.

Mr. Thiess: Those two articles, as I understand, are in evidence as our exhibits.

The Court: The Lochhead article?

Mr. Rathburn: The two he is talking about now are in as Exhibits 12— I guess the second one isn't in.

The Court: Exhibit 12 is a Lochhead article?

Mr. Rathburn: Yes.

The Witness: Exhibit 12 is marked on this one and the second one is the one following.

Mr. Greer: Take up Exhibit 12 first and tell us what you see in that report as a basis for his belief in
724 or disbelief in a doctrine of inhibition between different strains of Rhizobium bacteria.

A. He says:

"Furthermore, cultures containing bacteria for treating legumes of different cross-inoculating groups were unsatisfactory. Where two strains of Rhizobium are mixed in a single culture, there is the probability of one strain being suppressed, and it is therefore recommended that an inoculant contain bacteria of but one cross-inoculation group."

I couldn't state that as evidence that there is inhibition.

Q. All right. What about the other?

A. The other one says:

"Moreover the inoculants containing bacteria for but one cross-inoculation group are believed better than those containing bacteria for two or more legume groups since tests have shown that in mixed cultures one strain may become ineffective."

Q. All right, as a scientist, what would you say as to that supporting a doctrine of inhibition as a general
725 proposition?

A. I would say that would not show there is such a thing as inhibition.

The Court: Well, it shows he thinks there is, doesn't it?

The Witness: Inhibition was not known. He may be thinking that one group of bacteria grew faster. Well, bacteria occur in two divisions, roughly, what we call fast growers and slow growers. He may have believed that in the competition for food, one of this group was lost. There is so little in this sentence that a great many possibilities are possible.

Q. In your research into the doctrine of inhibition, did you have any contacts with Dr. Lochhead?

A. Yes, I had a letter from him shortly before coming here, and that letter is included among those that were submitted.

Mr. Greer: Q. Can you tell me, Doctor, in this research which you conducted whether or not you found any scientist who believed in the doctrine of inhibition?

726 A. No.

Q. Now, I will call your attention to another article which was in German. I don't think it has been introduced in evidence, has it? The German article, you had no translation of it was by— what is the name?

A. Weigert and Weizel, in an article entitled "Observations on the Influence of Previous Crops and Nurse Crops on the Development of Red Clover."

Q. Have you read that article?

A. Yes.

Q. You can read German?

A. Yes.

Q. Please tell us, what, if anything, you find in that article in support or in opposition, either one, to this doctrine of inhibition as to different strains of the bacteria Rhizobium?

A. It does not deal with that subject.

Q. What can you say as to the fact that in the genesis of this art of plant pathology dealing with the Rhizobium bacteria as to the belief originally among scientists with regard to whether there was only one or more than one species of the Rhizobium bacteria?

A. Originally it was believed that there was but

727 one specie.

Q. Now, can you tell us whether or not there is a school of thought in this art that still holds to that theory?

A. There is a growing school of thought that holds to this theory.

Mr. Greer: You may take the witness.

Cross-Examination by Mr. Rathburn.

Q. Dr. Hofer, in connection with these articles by
728 Dr. Lochhead—

A. Which articles?

Q. The last two, the 1934 and 1938. Did I understand you to say that statements you quoted from these two articles couldn't be taken as an indication of inhibition?

A. Oh, possibly someone might take them as a mere indication, but there are other possibilities that would have to be considered.

Q. Inhibition is a possibility, isn't it?

A. It is one possibility.

Q. And it is a fairly logical possibility?

A. No.

The Court: Let me have Plaintiff's Exhibit 12, please.

(Document handed to the Court.)

Mr. Rathburn: It is the last sentence. Will you mark this for identification as Plaintiff's Exhibit 18?

(Said letter was marked Plaintiff's Exhibit 18 for identification.)

Mr. Rathburn: Q. Have you ever seen that letter before? (Handing letter to witness.)

A. Yes, sir, I wrote it.

Q. Is that your signature?

A. Yes.

Q. And you wrote that letter to Mr. Bond?

729 A. I can't remember in what connection, but that is true.

Mr. Rathburn: Will you mark this Plaintiff's Exhibit 20?

Mr. Rathburn: Change this to 19, please.

(Said document was marked Plaintiff's Exhibit 19 for identification.)

Mr. Rathburn: This is Number 20.

(Said document was marked Plaintiff's Exhibit 20 for identification.)

Mr. Rathburn: Q. Dr. Hofer, do you recognize this letter that has been marked for identification as Plaintiff's Exhibit 19?

Q. Is that your signature?
A. Yes, it is.
Q. And you wrote that letter to Mr. Bond?
A. Yes.
730 Q. I believe you said you didn't recall in what connection you wrote the letter, Plaintiff's Exhibit 18?
A. No.
Q. Did Plaintiff's Exhibit 19 refresh your recollection on that?
A. Well, he was asking for information—
Q. Please answer the question.
A. Yes.
Q. The two letters are about the same subject?
A. I don't remember his letter before this one, so I can't remember what he inquired about.
Q. But your letter of July 29th, Exhibit 18, is directed to the same subject as your letter, Plaintiff's Exhibit 19?
A. That is correct.
Q. Is the article by Lochhead published in 1938 in the Report of Bacteriology For the Dominion of Canada the article you were referring to in the letter, Plaintiff's Exhibit 18?
A. Yes, I am sure it is.
Mr. Rathburn: Will you mark this for identifica-
731 tion as Plaintiff's Exhibit 20?
(Said document was marked Plaintiff's Exhibit 20 for identification.)
Mr. Rathburn: I show you a photostat, Dr. Hofer, of a part of this 1938 Lochhead Bulletin. Is the part underlined on the photostat the part you had in mind in calling this thing to Mr. Bond's attention?
A. That is right.
Mr. Rathburn: I now offer in evidence as Plaintiff's Exhibit 18 the letter dated July 29, 1938, addressed to Mr. Bond from A. W. Hofer.
Mr. Greer: No objection.
The Court: It may be received.
(Said letter dated July 29, 1938, addressed to Mr. Bond by Mr. A. W. Hofer, so offered, was received in evidence by the Court and marked Plaintiff's Exhibit 18.)
Mr. Rathburn: I offer in evidence as Plaintiff's Exhibit 19 a letter previously marked for identification—
Mr. Greer: No objection.

Mr. Rathburn: (Continuing:) —from Mr. Hofer to Mr. Bond.

732 The Court: It may be received.

(Said letter from Mr. Hofer to Mr. Bond, so offered, was received in evidence by the Court and marked Plaintiff's Exhibit 19.)

Mr. Rathburn: I offer in evidence as Plaintiff's Exhibit 20 photostatic prints of the title page and of pages 14 and 15 of the 1938 publication by Mr. Lochhead.

Mr. Rathburn: Q. In connection with this survey you made, Dr. Hofer, how many letters in all did you send out inquiring about this?

A. Well, there was about a dozen.

Q. Did you send a letter to Dr. Fred?

A. I don't believe so.

Q. Did you send one to Dr. Baldwin?

733 A. I did.

Q. Did you get a reply from him?

A. Not a reply to be used in testimony.

Q. I just want to know if you got a reply. Did you get a reply?

A. Yes.

Q. Did you send a letter to Miss McCoy?

A. No.

Q. Did you send a letter to Dr. Wilson, Dr. P. W. Wilson?

A. These people are all at institutions, different institutions, Dr. Baldwin at the University of Wisconsin, that was all in that letter.

Q. Did you write to Dean Burke?

A. No, he is not working in the field any more.

Q. Did you write to F. E. Allison?

A. No.

Q. Do you have a copy of your letter of inquiry?

A. I think so.

Q. May I see it? I believe you stated you were familiar with the literature in this field—

A. I am.

Q. (Continuing:) —in 1938?

734 A. I am.

Q. Have you ever seen the Kroenberger article prior to this trial?

A. Yes, I have.

Q. You are familiar with it?

A. Yes.

Q. In 1938?
A. No.
Q. When did you first become familiar with it?
A. I may have seen a reference to it or seen the article in 1938, but it isn't the kind of article that carries much weight.
Q. You didn't study the article? You couldn't say you knew what was in it at that time?
A. I knew enough about what was in it to form my own opinion of it, which wasn't high.
Q. When were you first engaged in connection with this law suit?
A. Well, about a year ago it first became known that this was coming up.
Q. That was before you ran these tests—
A. Yes.
Q. (Continuing:) —you have put in evidence, the tests on clover?
735 A. Yes.
Q. And were those tests made at the request of the defendant in this case?
A. Well, the tests came about in this way: I asked—
Q. Could you answer that question directly, Doctor?
A. No.
Q. They were not made at the request of the defendant?
A. No.
Q. For whom were they made?
A. I can explain it to you.
Q. All right.
A. I asked my immediate superiors about the matter, whether I should become involved in this. They said they would hesitate to say. They would like to have the director of the Experiment Station give his opinion, and he said, if I participated in this, I should be prepared to present the true facts of the case since there was little evidence available, practically nothing except what I myself had done. I ran this test in as thorough a way as I knew how to get the true facts in the situation.
Q. Did the defendant know you were running the test?
A. Yes.
Q. They financed it?
736 A. No.
Q. They did not finance it?

A. No.

Q. As I understand your test, you got five strains of clover bacteria, five strains of alfalfa bacteria and five strains of soy bean bacteria from Dr. Lochhead?

A. That isn't exactly right.

Q. Five of alfalfa clover and soy beans?

A. That is right.

Q. What did you ask for from Dr. Lochhead?

A. I asked for five effective cultures from each of those groups. In science we have to be awfully careful—

Q. I think you have answered the question. You asked for five effective cultures?

A. Yes.

Q. When you got those cultures, you prepared a mixed culture by growing all fifteen strains together for a period of two weeks?

A. That is right.

Q. At the end of that two weeks, you didn't really know how much of each strain you had in there, did you?

A. I did know.

Q. You could tell one strain of alfalfa from an 737 other strain of alfalfa?

A. No, but I knew how many clover and sweet clover and soybean were in that culture.

Q. How did you know that?

A. I made tests.

Q. That answers my question. You didn't know how many of each strain of clover you had in there?

A. No.

Q. You didn't know how many of each strain of alfalfa?

A. No, but they grew uniformly. If one strain had been inefficient it would have thrown it off.

Q. But you didn't know?

A. Not to any individual strain.

Q. And you didn't know as to how many strains of soy bean?

A. No.

Q. Did I understand you to say you inoculated the soil with this test instead of the seed?

A. Yes.

Q. I believe you also said that was standard practice today, didn't you?

A. In certain ways it is coming to be used.

Q. I am asking did you say that was standard practice?

738 A. Well, there are different purposes for which legume bacteria are used, and I can't say it isn't standard practice and I can't say it is standard practice.

Q. I will rephrase it. Is it standard practice to buy a package of Legume-Aid and inoculate the soil with it for field clover?

A. I recommend it for garden use.

Q. I asked for field use is it standard practice to buy a package only?

A. No, it isn't.

Q. It isn't standard?

A. It isn't standard.

Q. Dr. Hofer, I have got a little bit mixed up during your direct testimony. I can't tell which photographs relate to which of the tabulated data on this sheet.

A. The big photographs.

Q. The photographs show your test results?

A. In the photograph the right hand half of the experiment, the right hand seven rows of pots, all connected to that right hand flask, all those are clover.

Q. Those are all clover?

A. That is right.

Q. Are they all red clover?

739 A. That is right.

Q. All right. Now, which row of pots shown at the right hand side there correspond to the top horizontal column in your report, Defendant's Exhibit 29?

A. The one on the very right.

Q. The row marked '1'?

A. The row 1 in the table corresponds to the row 1 on the bench.

Q. And I assume it is the same as to 2 and 3?

A. That is right.

Q. That corresponds to rows 2 and 3?

A. That is right.

Q. And then row Zero is the control row?

A. That is right.

Q. And row 15 is the one where you used the mixed culture?

A. That is right.

Q. All 15 strains?

A. That is right.

Q. And rows 4 and 5, the 4 looks kind of like a 1, but I think it is a 4—

A. It is a 4.

Q. (Continuing:) —corresponds to the rows 4 and 740 5 on your test tables?

A. That is right.

Q. Did you in arriving at the results shown in test report, Defendant's Exhibit 29, apply any statistical analysis to your result?

A. You mean this table?

Q. This table.

A. No, because—

Q. I just asked if you did.

A. No.

Q. The answer is no. Then you couldn't tell usually—there isn't any standard deviation from the mean then if you didn't apply any statistics?

A. It is simpler this way.

Q. Returning to your photographs again, Doctor, to the one, Defendant's Exhibit 26, it is the one marked A—

A. Oh.

Q. (Continuing:) —what are the pots on the left side of the table?

A. Sweet clover.

Q. Did you make any report on them, any analysis and report?

741 A. No.

Q. You just grew them and didn't do anything with them?

A. I wanted to do something with them.

Q. But you didn't?

A. Insects got in and ruined the experiment.

Q. The photograph, Defendant's Exhibit 27, am I correct in the assumption that the pot at the extreme right with the 2 in front of it is the same pot as is shown in the second row of Defendant's Exhibit 26?

A. That is right.

Q. And in Defendant's Exhibit 28 the pots, I believe you said are the same as in 27 except that the numbers have been removed?

A. The numbers were not removed. The camera was too high to take them.

Q. But they are the same rows appearing in the same order?

A. That is right.

Q. I noticed from your report, Defendant's Exhibit 29, that you have only four control pots in the row, but you have eight pots in each of the other rows. Why was that?

A. May I explain?

Q. Yes, sir.

742 A. Toward the end of this experiment, when the sweet clover began to have insects in it, I spent quite a bit of time trying to keep the insects out of both the sweet clover and the red clover. One hesitates to apply chemicals to an experiment like this and the advice was that the simplest way to control the red spiders was to keep the greenhouse very humid and actually wash the plants with water.

Unfortunately when that was done a few stray bacteria were carried into those four pots and they began to show results that were not typical of the treatment that they had had.

I removed the pots, and shortly after that removed the whole experiment.

743 Q. Are you sure no stray bacteria got into any of the red clover plants?

A. Well, if that would happen it would make very little difference for this reason: The control pots were free of nodules, they were hungry for nitrogen. New bacteria falling on there would immediately work. The other plants were full of nodules of bacteria that were working, and a stray bacteria or two falling in there would have little effect on the hundreds or thousands or perhaps millions already there.

Q. Now, with respect to—

The Court: Q. They are in a better position than the defendant's plants?

A. Yes, they are already overridden by bacteria.

Mr. Rathburn: Q. Now, with respect to the report which you submitted on the comparison of satisfactory garden cultures as compared to other cultures over a number of years—

A. Yes.

Q. —you considered there only whether or not the bacteria were present, did you not?

A. Yes, whether the nodule formation was good so that the plants were in a position to go ahead and

744 develop nitrogen.

Q. You made no test to determine how efficient any of those cultures were?

A. No, except incidentally as we happen to see the plants and notice that they thrive particularly well.

Q. You could not remember now which ones were and which ones were not over this number of years?

A. No, just general impressions is all.

Q. You can't tell us much more than that the bacteria was there.

A. Were viable and active.

Q. Viable enough to form nodules?

A. Viable and active.

Q. Are you familiar with the method of statistical analysis known as the analysis of variance?

A. People get all involved in statistics and I try to design my experiments so that this will not be necessary.

Q. Doctor, please, are you familiar with the statistical analysis method known as the analysis of variance?

A. Not that particular method.

Q. Then when you testified with respect to what effect would be involved if you had only three pots as against five, you were not considering the effect that an
745 analysis by the method of variance might have on the result?

A. I considered these things with statisticians numerous times.

Q. But you are not familiar with the analysis of variance?

A. Personally I have not used that method.

Q. Now, with respect to your report on lima beans from two types of inoculants, Defendant's Exhibit 31, I understood you to say that the lima bean, the single culture inoculant that you used was nitragin.

A. Each year—I think I can give the exact date from my records at Geneva if that is still admissible—but each year I think Nodogen single strain and Nitragin single strain was used in comparison with the mixed culture of each.

Q. You say "with the mixed culture". You mean the mixed culture—

A. Of each of those two companies, using the same strains in the mixed culture as were present in the single culture.

Q. That is what I was going to get around to.
746 How did you know they were the same strains in the single culture and in the mixed?

A. I understand it is not possible to quote anyone in court, so—

Q. You did not know?

A. I did not know from my own experience.

Q. In connection with the field test that you made on mixed cultures and single cultures, garden cultures, they were, I believe, was your field setup approved by a qualified statistician?

A. Why, I did not take it to a statistician by running it, but it was discussed with statisticians previous, and each year I run similar tests in accordance with the advice of statisticians at our station.

Q. How was the setup randomized? Were you careful about that?

A. Absolutely. I made a layout of the plot and marked out the rows and gave each row a number, and then wrote that number on a piece of paper. I took those papers and tossed them up into the air and let them come down where they would, and then took those, beginning on one side of the room, picking up always the nearest one and putting that down, and then the next
747 one, and that is how—excuse me.

Q. We are talking about field tests.

A. Excuse me, that is right. I am talking about the field tests but I did not take the numbers of the pots, I took the treatments to be applied on the pots, and the first treatment, picking up, was put on the first pot, the second on the next pot, and so on clear through the whole field.

Q. In connection with the amount of variation that is encountered in field tests and as compared with greenhouse tests, where you start with sterile sand, isn't it a fact that in the greenhouse tests the amount of variation can be held to a minimum by a skillful operator as compared to an unskillful operator?

A. Well, I don't know what to say about that. We assume that a skillful operator will run the tests or they won't be run.

Q. That is a nice assumption, but assuming that an unskilled operator runs a test in the greenhouse, he will get a much wider variation than a skillful operator?

A. An unskilled operator would probably mess up
748 the whole thing.

Q. Just going back one minute to your tests reported in Defendant's Exhibit 29, that is, the clover tests

again; when did you advise the defendant that you were making these tests?

A. I don't recall.

Q. I don't mean as a matter of date. Was it before you started the tests or after?

A. I think so, I think I told him that I was going to run the tests.

Mr. Greer: May it please your Honor, I would like for the record to show that counsel for the plaintiff requested the witness to produce the letter which he wrote to the scientists requesting their opinion, and that letter has now been produced and shown to counsel for plaintiff.

The Court: All right.

Mr. Rathburn: Will you mark this for identification as Plaintiff's Exhibit 21?

(Letter of Dr. Hofer to scientists requesting their opinion was thereupon marked as Plaintiff's Exhibit No. 21, for identification.)

749 Q. I show you this letter, Dr. Hofer; is that a copy of the letter that you circulated in connection with this survey?

A. Yes.

Mr. Rathburn: I offer in evidence this letter as Plaintiff's Exhibit 21, just identified by the witness.

753 The Court: All right, then Plaintiff's Exhibit 21 is received. Read it so I will know what the question was.

754 Mr. Rathburn: This particular letter is addressed to Dr. Conn, at the New York Agricultural Experiment Station, Geneva, New York. (Reading)

"You may have heard of the lawsuit now pending between two inoculant companies and which is scheduled to go to court in the near future."

I might digress to say the letter is dated May 18, 1945. (Continuing)

"I am told that it will be necessary for me to testify, and since certain questions are involved that deal with problems with which you are familiar, I am wondering whether you would be willing to give me the benefit of your opinions.

"Briefly, the question at issue resolves around certain statements in the patent. One is: 'It has heretofore been considered impracticable to prepare a composite culture inoculant containing organisms

which will cause nodulation on more than one of the cross-inoculation groups. This has not been done
755 because it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organisms was inhibited or even prevented. For this reason it has been considered desirable to use a culture containing a single species of organism rather than on—"

I think that is a misprint and should be "one".

"—containing a mixture.

"Also: 'As has been pointed out above, composite cultures for inoculating the seeds of leguminous plants have not generally come into use because of the inhibitory effect that certain strains of certain species of Rhizobia have on each other.'

"A good deal of the case hinges around this question of inhibition of nitrogen fixation in one group of bacteria over a different group. Because of the importance of this point, I should appreciate knowing whether or not you believe that such an effect
756 actually occurs. The more answers there are to this letter obviously the better will be the measure of scientific opinion on the subject.

"Unless you object, it is my plan, if and when I am called, to include your answer with the evidence.

"Assuring you of my great appreciation for any support you may give me in presenting this matter fairly, I am

Sincerely yours,

A. W. Hofer."

Mr. Rathburn: That is all.

757 Mr. Greer: I offer as Defendant's Exhibit 34, a certified copy of the file wrapper and contents of the Bond patent in suit, No. 2,200,532.

The Court: It may be received.

758 (Said document, so offered and received in evidence, being certified copy of the File Wrapper and Contents in the Matter of the Letters Patent of Varley Sherman Bond, assignor to Kalo Inoculant Company, Number 2,200,532, granted May 14, 1940, for Improvement in Bacterial Inoculants for Leguminous Plants, was thereupon marked as Defendant's Exhibit No. 34.)

759 Mr. Greer: And likewise photostatic copies of page

114 of this book of Fred, Baldwin, and McCoy, and I would like to state that this photostatic copy has some underscoring or notes on the side of it, and I am not trying to say that that underscoring is in the original book. It was on the original pages and has been reproduced in this photostatic copy.

The Court: That is Defendant's Exhibit 35?

Mr. Greer: 35, yes.

The Court: Yes, it may be received.

(Said document, so offered and received in evidence, being photostatic copy of page 114 of book entitled "ROOT NODULE BACTERIA AND LEGUMINOUS PLANTS", by Fred, Baldwin, and McCoy, was thereupon marked as Defendant's Exhibit 35.)

760 Mr. Greer: And also photostatic copy of page 136 of the same publication.

The Court: That will be Exhibit 36. It may be received.

(Said document, so offered and received in evidence, being photostatic copy of page 136 of book entitled "ROOT NODULE BACTERIA AND LEGUMINOUS PLANTS", by Fred, Baldwin, and McCoy, was thereupon received in evidence as Defendant's Exhibit No. 36.)

Mr. Greer: And with that the defendant rests.

Whereupon the defendant rested its case.

761 Mr. Greer: For the sake of the record and so that there can be no confusion about it, with regard to Defendant's Exhibits 5, 6 and 7, which were the Curie reports, I understand you object to them, Mr. Thiess, on which you asked the judge to withhold his ruling until you had the opportunity to put Mr. Curie back on the stand, and you decided not to put him back on the stand.

The Court: They may be received;

(The summary headed: EFFICIENCY OF CLOVER BACTERIA AS AFFECTED BY ALFALFA BACTERIA, dated October 27, 1944, was received in evidence as Defendant's Exhibit 5.)

762 (The photographs (Defendant's Exhibits 6-A to 6-L, inclusive for identification), showing 2 rows of five jars in each row on each photograph, with plants therein, showing heading above top row of: CLOVER, headings in the center between rows as follows: CLOVER BACTERIA 202, 2A1, 2A2, 2A3, 2A4, 2A5, 2A6, 2B1, 2B2, 2B3, and 2B4, and: 12 STRAINS CLOVER BACTERIA, respectively, on said respective photo-

graphs; and the heading below the bottom row of jars on each photograph: PLUS 12 STRAINS ALFALFA BACTERIA, was received in evidence as Defendant's Exhibits Nos. 6-A to 6-L inclusive.)

(The document entitled: THE EFFECT OF ALFALFA NODULE BACTERIA RHIZOBIUM MELILOTI ON THE ACTIVITY OF CLOVER NODULE BACTERIA RHIZOBIUM TRIFOLII, by I. H. Curie was received in evidence as Defendant's Exhibit 7.)

Mr. Rathburn: Before examining our first witness, your Honor, I want to offer in evidence as Plaintiff's
763 Exhibit 22 the translation of the article by Gerlach and Vogel, about which Mr. Bond testified during his testimony on prima facie.

The Court: Plaintiff's Exhibit 22, the translation of the Gerlach and Vogel article, may be received.

(The English translation of article by Prof. Dr. Gerlach and R. Vogel, entitled: OBSERVATIONS ON THE ACTION OF HILTNER'S PURE CULTURES FOR LEGUMES (Report of Kaiser Wilhelm Institute for Agriculture, Bromberg, Germany) was received in evidence as Plaintiff's Exhibit 22.)

764 WHEREUPON THE PLAINTIFF, TO FURTHER MAINTAIN THE ISSUES ON ITS BEHALF, OFFERED AND INTRODUCED THE FOLLOWING EVIDENCE IN REBUTTAL, TO WIT:

WAYNE WILLIAM UMBREIT was called as a witness on behalf of the Plaintiff, and having been first duly sworn, was examined and testified as follows:

Direct Examination by Mr. Rathburn.

Q. Will you please state your full name and your present address?

A. Wayne William Umbreit, 130 University Avenue, Ithaca, New York.

Q. Will you please state your age and your present occupation?

A. Age, 32; occupation: Associate Professor of Bacteriology at New York State College of Agriculture, New York State College of Agriculture, Cornell University, Ithaca, New York.

765 Q. What is your education and research background which qualifies you to testify as an expert in the case involving the questions of root nodule bacteria that are involved in this litigation?

A. Bachelor of Science, Wisconsin, 1934; Master of Science, Wisconsin, 1936; Doctor of Philosophy, Wisconsin, 1939. From the period of 1934 until 1937 I was engaged in research at Wisconsin under Dr. P. W. Wilson on the mechanism and biochemistry of this nitrogen fixation process.

From 1938 on I was engaged in the production of the University's inoculation cultures and did some research on the subject. That extended until July 1, 1944.

In the interim I was wholly at Wisconsin, except for a period of one year, 1937-1938, when I was at the New Jersey Laboratory, with Dr. Waksman.

Q. Since January 1, 1944, is that the date you gave?

A. July 1.

Q. You have been in your present position at Cornell?

A. Yes.

Q. Dr. Umbreit, as you were familiar with it, in 1938, what was the prevailing scientific opinion regarding the use of mixed cultures for legumes?

766 A. Well, as I understand it or understood it at the time, the mixed culture was not very popular; it was not considered a successful culture.

Q. They were on the market at that time?

A. Yes, the garden cultures certainly were on the market.

Q. Why, in your opinion, did this rather discouraging view of mixed cultures prevail?

A. Well, it seems to me that, first of all, people were not too interested in preparing one and the other thing was that the ones that had been prepared had not been very successful. It did not look like a good bet to try it.

Q. In 1938 what is your view of scientific opinion in connection with the existence of inhibitory strains?

A. I doubt whether in 1938— Well, certainly I did not believe in the existence of inhibitory strains in 1938, and I doubt whether other people did.

Q. Why didn't you agree with it in 1938?

A. Well, I never studied the subject. I wasn't interested in it. It never occurred to me that this sort of thing might occur.

Q. I believe you said that you thought that was the prevailing opinion?

A. Yes.

767 Q. How do you explain this when in the literature, —at least, the Kronberger article,—had shown inhibition?

A. Well, I don't think very many people read the Kronberger article. Thousands of papers are published each year on legume bacteriology and one certainly doesn't get to read all of them.

Q. You are familiar with the Kronberger article now?

A. Yes.

Q. In your opinion does the Kronberger article point to the existence of inhibition?

A. Yes, in my opinion it does.

Q. After the appearance of the Bond patent and UNICULTURE on the market, was there any scientific work done at the universities with which you are familiar on the problem of inhibition?

A. Not that I know of.

768 Q. Why do you think that no work was done?

A. Well, that was along about the time the war was beginning to hit us and we didn't have time or facilities to do it. I think that in the future it will probably be studied quite intensively.

Q. In your opinion do inhibitory strains of legume bacteria exist?

A. I believe so.

Q. On what basis do you form that belief?

A. Well, first Kronberger has demonstrated that by mixing cultures such inhibition is obtained. So far as one is able to tell, that is the sole difference,—the strains which are having fixation and the ones that are showing this inhibition,—is the ones that show the inhibition have been mixed together.

Then there is, as there have been introduced in this trial, some further earlier reports which would indicate that, though I wouldn't be able to prove it, and then there is the work of Mr. Bond which shows exactly the same thing, that if you mix these cultures, which is the sole difference between them, this inhibition is obtained.

Now, I wouldn't see how you could avoid, whether you like it or not, however you interpret that, the con-

769 clusion that there are inhibitory strains.

Q. Do you know if there is any evidence that inhibitory strains do not exist?

A. No, I do not.

Q. Do you believe that non-inhibitory strains do exist?

A. Oh, yes, I am quite certain of that. There certainly has been plenty of evidence introduced into this trial that noninhibitory strains exist. Certainly the experiments of Dr. Erdman show that when some strains are used, no inhibition is obtained.

Dr. Hofer's show the same thing; those of Mr. Curie, although there is very considerable variation occurring in them, probably show the same thing.

The Court: You said noninhibitory strains?

The Witness: It is my conviction both exist.

The Court: The latter must be true or else the product isnt any good?

The Witness: I don't think there is any question about it.

The Court: I am talking about both sides.

The Witness: That is right.

Q. (By Mr. Rathburn) The validity of the experiments on which you base your conclusion as to inhibitory
770 strains has been questioned. What do you have to say about that?

A. Well, I think we could take up first the Kronberger experiments. They have been criticized as not showing that inhibitory strains existed, on the ground that the techniques were not standard.

There were three reasons that the technique was not standard. One was that soil humus mixture was used which is not the sort of thing we use for testing this thing now. But it seems to me the point is that this was used constantly in all of the pots and that still there were differences between these pots.

Now the sole difference that we can put our finger on is that in one case the things were mixed together and in the other case they weren't.

The next one was that the soil was not sterilized. Well, there were controls in these experiments and then the addition of bacteria caused an increase.

The third thing—

Q. Sterilization of the seed—

A. —oh, yes, the sterilization of the seed was too vigorous. The only thing one can say is the plants grew and were able to fix nitrogen.

Now while that is a very drastic treatment, that would be more or less in opposition to what Kronberger
771 wanted to show, or at least was showing in his paper;

you would think that if you had some harm there it would reflect on the growth of his plants or their ability to fix nitrogen and that apparently wasn't the case.

Furthermore, more drastic treatments of seed sterilization have been used in the field. It is a drastic one but not too drastic. The evidence is that the plants grew and fixed nitrogen.

Q. Then I take it that you believe these experiments in the Kronberger article are valid?

A. I believe they are valid.

Q. Do you know, aside from anything that has been introduced in this case, of any other reasons why these experiments of both Kronberger and Bond should not be accepted?

A. No, I do not.

Q. I call your attention to a chart which is in evidence as Defendant's Exhibit 8, Dr. Umbreit; have you examined that chart (handing document to the witness)?

A. Yes.

Q. On the basis of what is shown in Series 2 and 4, would you conclude that there was inhibition?

A. Yes, in this experiment I would conclude that there is inhibition. The things that you have to compare, 772 here, as you pointed out, are 2 and 4.

The sole difference between them is 4 was mixed with alfalfa. Otherwise, this whole set-up is the same.

Now the total variations have been plotted here and these two are different. Some inhibitory effect has been caused by this mixing. The total range is plotted here and these do not come from what a statistician would call the same population.

That is, these are two distinct differences, that this difference, in spite of the variation is real, that these come from two different kinds of things.

Q. Have you had any experience, Doctor Umbreit, in attempting to evaluate greenhouse tests for nitrogen content by visual observation?

A. Yes.

Q. What do you think about visual observation as a test?

A. Well, if you don't have anything else you can use it. It is not very accurate. The 20% or 30% or 15%, that has been brought out in the trial,—we will say 15% will be reasonably good, but every once in a while you can get terrifically fooled on them because of bunch-

ing and because of greenness and other variations which your eye doesn't take in.

773 Q. Would you accept the conclusions of a scientist as to nitrogen fixation who had made nothing except visual observations if he was within 25%?

A. No. You simply can't tell that. If his differences are big, that is another thing.

Q. You have been present in the court since the start of the trial, have you?

A. Yes.

Q. As you may recall, Mr. Curie testified that in some measurements with respect to their LEGUME-AID he had found a growth or an increase of about 40 times over the 5-day period in which the mixture was allowed to stand before packaging.

I think he said he couldn't be very accurate about it but he did have one which was 40 times. What would you say as to that with respect to whether it was a normal growth or a retarded growth of root nodule bacteria in that length of time?

A. Well, 40 times is not very large. You see, we are dealing with numbers that are up in the billions in the first place and our methods of measuring things that large are not too good, and a difference of 100 or 1000 times we would place some question on. As a matter of

774 fact, if the difference were 100 times with populations that large we would say: Well, maybe these are different but not very much.

Mr. Rathburn: That is all.

Cross-examination by Mr. Greer.

Q. All right; just a question or two, Dr. Umbreit. As I understand you, you believe now that there is a strain of this Rhizobium bacteria that is inhibitive when associated with another strain, and there are other strains which are not inhibitive.

Am I correct in that being your opinion?

A. That is right.

Q. Now this question of inhibition or lack of inhibition is a work of nature, as I understand it, is it not?

A. As far as my opinion would go that is absolutely so.

Q. I didn't understand.

A. As far as my opinion would go that is absolutely so.

Q. Well, that is what I am asking for, just your opinion.

A. Yes.

Q. You know of nothing that the man does that brings about this state of inhibition or lack of inhibition, in other words?

775 A. That is right.

Q. You are familiar with the Bond patent, are you not?

A. I am.

Q. Is there anything in that Bond patent, in your opinion, that shows how to prevent inhibition or how to bring on inhibition?

A. With an inhibitive strain there is nothing in the patent that I know of which tells how to prevent that inhibitive strain from inhibiting. But it does tell you also that noninhibitive strains exist and if you use these, you will not have this difference. That is the way I interpret it.

Q. Assuming the fact that there was a non-inhibitive strain, it wouldn't take anybody else's teaching to leave one skilled in this art know that if there was an inhibitive strain, it was going to inhibit something, isn't that right?

A. Yes.

Q. Now, just one more question on this chart, Defendant's Exhibit 8. As I understood your direct examination you took the comparison between the chart which is Number 2, the showing under the heading Number 2 and Number 4?

A. Yes.

776 Q. According to that chart, just looking at the chart, not taking in your statistical analysis or anything of that kind, that does show a variance, doesn't it, between those two?

A. Yes.

Q. And Number 2 is an inoculation of a leguminous plant with a single inoculant, as I understand it, and Number 4 is an inoculation of a leguminous plant with a mixed culture?

A. Yes, sir.

Q. Now, what would be your opinion as to a possibility that there might be that same variance if you were using a single inoculant in Number 2 and the same single inoculant in Number 4? Is there a possibility of that same variance showing up?

A. You mean in a different experiment?

Q. Yes, I mean in a different experiment.
A. That you can't tell. You have no knowledge of that.
Q. I am asking your opinion as to the possibility?
A. Yes.
Mr. Greer: No further cross-examination.

777 *Redirect Examination by Mr. Rathburn.*

Q. In the same experiment with the same strain of single culture, would you expect a difference like that to show up, Dr. Umbreit?
A. No. The thing is my interpretation of both answers would be that if you had a difference which showed that these two came from two populations there was something different about those two populations, whether you knew what it was or not.
Mr. Rathburn: That is all.
Mr. Greer: Nothing further.
(Witness excused.)

ROBERT H. BURRIS was called as a witness on behalf of the Plaintiff, and being first duly sworn, was examined and testified as follows:

Direct Examination by Mr. Thiess.

Q. Will you please state your name, residence, and present occupation?
A. Robert H. Burris, University of Wisconsin, 778 Madison, Wisconsin; Assistant Professor in Biochemistry.
The Court: Did he ask you to state your age?
The Witness: 31.
Q. (By Mr. Thiess) Dr. Burris, what training have you had which would qualify you to testify as an expert in a case involving legumes and the inoculation of legumes by bacteria, as set forth in the patent in suit?
A. I received my Bachelor's degree from South Dakota State College in 1936. During the years of 1935 and 1936 as an undergraduate, I worked in the South Dakota Experiment Station Chemistry Laboratory.
In the summer of 1935 I worked in the Agricultural Bacteriology Department, at the University of Wisconsin; from 1936 to 1940 I was Research Assistant in the De-

partment of Agricultural Bacteriology at the University of Wisconsin; I received an M.S. in Ag. Bacteriology in 1938 and Ph.D. in 1940. 1940-1941, National Research Council Fellow with Professor Harold Urey, Columbia University, New York City. 1941-1944, Instructor in Ag. Bacteriology, University of Wisconsin; July 1, 1944 to
779 the present, Assistant Professor Biochemistry, University of Wisconsin.

Q. Now, Dr. Burris, as a plant biochemist, do you believe that you can estimate the nitrogen content of a plant to an accuracy of 10%?

A. By appearance, that is?

Q. Yes.

A. No; that is quite outside the range of a reasonable expectation for accuracy merely by visual appearance. I would place a more reasonable level at 20% to 25% with the possibility that under certain nutrient deficiencies you might be out of line even to the extent of 33% to 35%.

Q. Why do you answer this in this manner?

A. It is very difficult to have,—to judge a plant merely on the basis of its size. If your plant is bunched up or one is stalky and one is spindly, that throws you off in your estimate.

If you try to judge on the basis of color you find that perhaps the most frequent deficiency, sometimes, in plants is the chlorosis, that, is a yellowing.

Not only does nitrogen give you this chlorosis but many other nutrient deficiencies give you this result so it is quite impossible to estimate with any great
780 accuracy, although you can make a rough estimate.

Q. What do you consider a valid method to determine the nitrogen fixing ability of Rhizobia, single, and in mixtures?

A. The only valid method I could think of at the present time would be to take your seeds, sterilize them, that is, surface sterilize by aseptic procedure, plant them in sterile sand, that is, low nitrogen substrate, inoculate the seeds, grow the seeds, harvest the entire plant, and submit them to a Kjeldahl chemical examination, so that you have the actual chemical analysis of the nitrogen content and include in this proper uninoculated controls so that you know the validity of your experiment at the end, to indicate whether you had any stray con-

tamination and your controls should be subtracted from your other data in your calculation.

Q. And in such an experiment would you analyze only the tops of the plant?

A. That might be misleading. It would give you a general picture of the situation but the top-root ratio in plants is influenced by a number of factors and although, as I say, you would get a general indication of results, I would not consider that a desirable type of experiment.

781 Q. And what have you to say regarding a practice of discarding controls in an experiment of this character?

A. I am afraid that that would have to rank as rank heresy in experimental work.

Q. (By Mr. Thiess) Have you examined the data submitted by Mr. Curie in support of his contention that inhibitive strains of Rhizobia do not exist?

A. I have looked over that data.

Q. And what is your opinion of Mr. Curie's data?

A. Well, in looking over the data you find a variation between replicates as great as 12 fold. Any such variation as that scattered through the data would make you very suspicious of drawing any conclusions from it.

782 Q. Have you had any training in the use of statistical methods?

A. Yes, I did take a course in statistics from Dr. Churchill Eisenhart of the University of Wisconsin.

Q. What would you say constituted a valid statistical test of plant experiments such as have been under discussion in this litigation?

A. You can make a valid analysis by determining the standard deviation of your results and comparing the standard deviation between your samples you wish to compare, and see whether your two populations overlap.

You can interpret your results to find out at what level these results may be significant, whether they are significant three times out of four, or whether they are significant 19 times out of 20. The distinction, of course, results.

A more rigid statistical analysis is an analysis of variants such as introduced by Dr. Fisher some 20 years ago and has been developed since. That is a more rigid test than merely a determination of your standard deviation.

Q. Now, being qualified by your previous training,—
if you were qualified, I will put it, by your previous
783 training to produce legume inoculant commercially,
would you, if you were in such a business, rely upon
visual tests for estimation of nitrogen fixation of the
strains of Rhizobia you employed?

A. No, I would certainly employ an analysis involving actual chemical nitrogen analysis. The purported difficulties of such analysis are not so great. It is really very routine and simple procedure, unless you have 10,000 plants to analyze, in which case it would involve considerable time.

But that is the most valid estimate of your nitrogen fixing ability and the method is valid to 1% to 2%, which is about at least ten times as accurate, more than ten times,—probably twenty times as accurate as your visual analysis and hence I think it definitely would be adopted.

Q. Have you ever encountered any data in the literature indicating that mixed garden cultures have been tested for their efficiency in nitrogen fixation in comparison with the single constituent strains?

A. I have never encountered any published data indicating that mixed garden cultures have been tested against single constituent strains for their nitrogen fixing
ability. The only thing you have published on garden
784 cultures are the various tests from the State Agri-
cultural Stations and the Ag. Markets Department, indicating plus or minus nodules and sometimes, occasionally visual tests to say successful or unsuccessful in relation to the efficiency of the strain, but no actual analysis, although I think this afternoon perhaps some very late ones, unpublished work has been introduced.

Q. What is your recollection of the opinion in the art prior to the Bond patent regarding the cause of the general failure of mixed legume inoculants?

A. That is a very difficult question to project one's self back to 1936 or 1937. At that time I was at the University of Wisconsin which has been a center of work in this nitrogen fixation field and I must say that there was practically no discussion of the matter.

Nobody was greatly interested in it. They thought,—it was the general opinion that mixed cultures were unsuccessful. That had been the experience. There had been several on the market. They had gone off the market merely because they were unsuccessful.

Nobody was particularly interested in it. They were opposed to mixed cultures but they didn't bother themselves much with determining why these unsuccessful
785 results had accumulated.

And their disinterest was probably reflected in the fact that they didn't even bother to look up in the literature about this specific problem to say nothing of actually running tests themselves to back them up.

We just can't find much data in the literature on it. Nobody was particularly interested in it or worried about it. I think to actually say what the opinion was at that time would be a most difficult thing.

The Court: You mean speaking generally?

The Witness: Yes.

The Court: You have told him what it was in Wisconsin.

A. (continued) They knew mixed cultures were unsuccessful. They were dead set against them and I think that was the general opinion but the source of that difficulty no one was very much concerned with. They had more or less thrown mixed cultures out the window and weren't bothering themselves much about it because of inefficiency.

Q. (By Mr. Thiess) Now, Dr. Burris, do you believe that the statement by the patentee in the patent in suit that: "It was generally believed that one species produced an inhibitory effect upon another species within the same culture whereby symbiotic nitrogen fixation
786 by the plant and the organism was inhibited or even prevented", was an unwarranted statement?

A. No; I think it would be very difficult to say that was an unwarranted statement. As I said, most people hadn't looked into the literature. Now, in retrospect, when we do look over the old literature, we find there was very little existent and that which is existent, the best data suggests that an inhibition might occur, so I think it was perfectly logical in reading the literature and evaluating it and taking the conclusions of authors such as Kronberger, that Mr. Bond could have come to the conclusion that that was the general opinion.

Q. Do you consider that the Kronberger experiments were performed by valid methods?

A. Yes, I can't see any particular objections to them.

Q. Now, what is your opinion as to how long soil will have to be treated in an autoclave to properly sterilize it?

A. Well, the Rhizobia, of course, are very sensitive to heat and this experiment as it was stated, was interested in the root nodule bacteria Rhizobia, and holding them for ten to 15 minutes at 53 degrees or 54 degrees Centigrade will kill them off, if they are in water
787 suspension. If they are in soil it would obviously take more rugged treatment than that.

But I would say that the 121.8 degrees Centigrade that you get at 15 pounds steam pressure would, most assuredly, kill them off in 15 to 20 minutes in a pot of soil such as Mr. Kronberger used.

There was not a very large pot that he used, one with 2 1/2 kilograms of sand and one kilogram of this humus material. I think you would anticipate that Rhizobia would be killed off in well less than 15 or 20 minutes.

That certainly would assure there being killed off since the rate at which they are killed goes up very rapidly with an increase of temperatures; that is, a 10 degree rise in temperature doubles the rate of rise at which you would kill off the organisms, since they are sensitive at low temperatures.

Q. Does that increase geometrically as you go on up the scale?

A. Not quite geometrically but there is a rather more rapid increase than you might expect in the killing rate.

Q. Do you consider the sand humus soil used by Kronberger as objectionable?

A. Kronberger was using quartz sand and proba-
788 bly with treating the soils, he thought: Well, quartz . . . sand like that didn't quite simulate the soil,—he wanted to get in a few of what the soils-man would call base exchange compounds, that is, the plant nutrition; the plant gets its nutrients by the process known as base exchange.

That is, the plant gives off hydrogen ions from the roots in exchange for calcium and magnesium ions, an exchange very comparable to the exchange of sodium and magnesium in a zeolite water softener.

And he probably put in some colloidal material to give him some base exchange compounds. In putting in this humus he would introduce nitrogen. He didn't have such low nitrogen substrate as is used in many experiments but the key thing to keep in mind is that Kronberger included uninoculated controls and at least gave his results for the uninoculated controls, and his inocu-

lated plants showed a stimulation over that, so that the soil factor was taken into consideration by his control plants.

Q. Now, would you say that the soil that Mr. Kronberger used was more objectionable than the soil used by Dr. Manns, referred to in his Bulletin and in his patent?

A. Well, since he used in the Manns experiment,—
if you examine the data you find he used 8,000 grams
789 of a straight compost in which he plants, and this being in his favor as being rich in nitrogen, I would say it was not certainly not more objectionable in the case of Kronberger than in the case of Manns, with respect to the soils used.

Q. And you refer to these 8,000 grams of humus. Why would you say that was objectionable?

A. Well, it contains a very large amount of nitrogenous nutrients, and if you examine the data you find numerous instances where the data are reported: No nodules, excellent growth.

And the only conclusion is that the plants were getting the nitrogen nutrition under such condition from the soil substrate and not from the air.

Q. And can you tell the court why Kronberger added soil to his sand?

A. Well, as I pointed out before he probably wanted to add some base exchange materials and to more closely simulate soil conditions.

Some people have a little objection to using a straight quartz sand for their experiments although it can be used quite successfully.

Q. In your opinion would 1% mercuric chloride be
injurious to the seeds employed in this test?

790 A. No; I don't see where that has any valid, that is, particularly valid objectionableness, because the plants germinated, the bacteria infected the plants and formed root nodules, nitrogen was fixed, and again we have the controls there to take care of the matter, and as for 1% mercuric chloride being particularly a vigorous treatment many of these leguminous seeds, the small seeds especially, have very tough coats and certain of them, before they can germinate, have to be scarified by a treatment of an hour or two in concentrated sulphuric acid, so they have a very tough seed coat, and the acid can be washed off quite readily with sterile water.

Q. Do you believe that that,—that Mr. Kronberger's conclusions that the antagonism of the Rhizobia in the mixture in regard to their nitrogen fixing ability is a reasonable one?

A. I think it is perfectly reasonable, but it may indicate that when he mixed the strains together he got less fixation than when he used them singly, and he had adequate controls in his experiment.

In his conclusions he surveys the possibilities and he suggests that maybe it was just a lack of sufficient growth by the organisms, but he does away with that argu-
791 ment that he raises to himself, and comes to the conclusion that his data indicate inhibition and I think he has a valid point.

Q. Do you know of any other data indicating that inhibitory strains of Rhizobia exist?

A. There really isn't very much data in the literature indicating that. There is the data in the patent and in the testimony; more data has been introduced by Mr. Bond, and the defendant has introduced the case of Mr. Currie's experiment in which they state statistical analysis indicates a valid case of inhibition there.

So I would say that the literature is scanty but there are indications that inhibitory strains do exist.

Q. Do you know of any published data to indicate that strains of Rhizobia mutually inhibitory with regard to their nitrogen fixing ability do not exist?

A. No, I know of no published data in the literature indicating that inhibitory strains do not exist. I don't think that any published data has been introduced. All that has been introduced is material that has been accumulated since the start of this litigation and as yet unpublished in any journal.

Q. Do you believe that the data in the Bond
792 patent are indicative of the existence of mutual inhibition of the nitrogen fixing ability of Rhizobia of different cross-inoculation groups?

A. Yes, I think that is the only logical way to interpret the data. He set up the experiment in which he has set up a single strain alone and then combined that strain with a strain of organisms from another cross-inoculation group, the only variation being the addition of this other strain of organisms, and he has observed a depreciation in the growth of nitrogen fixation which is statistically valid and I think the conclusion is perfectly logical that this depreciation can be attributed to

an inhibition of the nitrogen fixing ability of the organisms in association.

Q. Now in your opinion as a man skilled in the art, is there any reason to suppose that the existence of an inhibition as described in the patent would be scientifically illogical?

A. No, I think that it is quite logical that you could have inhibition between these strains of Rhizobia. There are many cases of antagonisms between micro-organisms, say, for example, the case of penicillin and that is a mold, of course, but among the bacteria you have-
793 Bacillus brevis, which gives you gramacidin and which is a powerful antibiotic.

Inhibitions between micro-organisms are regularly observed in the art. Certain strains seem to have no effect on each other and, in addition, you will find strains growing in association which will stimulate each other. One may form vitamins and pass it on to the other and stimulate it.

There are mutual interactions like that. To assume that all these Rhizobia either are perfectly innocuous to each other or that they all stimulate each other mutually, would be a rather untenable position.

To say that a mutual interaction in the other direction cannot exist I would say would be a very illogical position.

Mr. Thiess: That is all.

Mr. Greer: No cross-examination.

(Witness excused.)

VARLEY SHERMAN BOND being previously sworn, was called as a witness on behalf of the plaintiff on rebuttal, and testified further as follows:

Direct Examination by Mr. Thiess.

794 Q. Mr. Bond, since you were on the stand on your direct examination in chief, this chart, Defendant's Exhibit 8, has been introduced in evidence.

Will you please discuss that chart and state whether or not that chart properly interprets the data in your patent and whether it does or does not show inhibition?

A. The defendant has altered the columns,—the hypothetical columns representing the nitrogen fixed per 10

plants of clover, in the case of the No. 3 Selected Strain.

There is no logical reason to assume that an average of Strain 2, which is not significantly different than the average of Strain Number 3, could be transferred from one series to another in this fashion.

According to the standard deviation there are no real differences between the columns in 2 and the columns under Number 3 and no competent statistician would pay any attention to this apparent difference.

There is no validity whatsoever for putting the green columns in this chart.

That also applies to the portion under Number 5. Even if there were a real difference between the two, that is even if the average of Number 2 was significantly different than Number 3, there would be no possible
795 excuse for mixing these two unrelated tests. The clover strains used under Series 2 were entirely different strains than those used under Series 3.

Just reviewing the chart, there is obviously a significant difference between Numbers 2 and 4, both of which contain the same clover strains, except in the case of 4 it was mixed with alfalfa.

And likewise there is no significant difference between Series 3 and Series 5, which both contain the second series of clover strains. In Number 3 the strain was tested alone and in Number 5 it was tested with other strains and there was no significant reduction in yield due to this mixture or association of the other strains with the clover.

Q. Now, Mr. Bond, I would like to discuss with you the prior art which has been introduced in evidence by the defendant and upon which they rely.

Have you read these various patents upon which they rely and are you familiar with them?

A. Yes, I am.

Q. I now direct your attention to the George Herbert Earp-Thomas Patent, Number 865,965, and I wish to ask you if a plurality of different species of root nodule
796 bacteria were grown together to form a composite culture by methods described in lines 57 to 100 of page 3 of this patent, would it be possible to predict whether or not the final culture would contain a sufficient number of bacteria of each species to inoculate each of the cross-inoculation groups for which the mixed culture purports to be effective?

A. It would be impossible to insure having each species there in sufficient numbers after a reasonable period of storage so that they would thoroughly inoculate the roots of the respective host plants to which they may be applied.

Q. And why do you say that it would be impossible?

A. There is variation in the rate of growth of the different strains of bacteria, and when they are grown together for a long period of time on the same jelly slant which was used in this case, one or more of the strains may over-grow the others and eventually there would not be a sufficient number of slower-growing strains in that culture after it had been on the dealer's shelf for a time.

Q. At lines 85 to 110 on page 1 of the patent, the patent indicates "that there is only one species of root nodule bacteria and that such bacteria are modified
797 by the food of the plant by which they live so as gradually to become adapted to a new host plant". Is this statement in accordance with present knowledge and accepted scientific opinion?

A. There is no proof that the characteristics of the bacteria in respect to infection of different cross-inoculation groups may be effected by the food upon which they live.

Q. What is the present opinion and on what do you base that?

A. The present opinion is that one specific organism will only inoculate its specific host plant, cross-inoculation group.

Q. There are a certain number,—6 cross-inoculation groups?

A. Yes. There are more than that. There are six important groups, commercially.

Q. Now, referring you to lines 88-93 of page 2 of this Earp-Thomas patent, the patentee there indicates that root nodule bacteria growing and multiplying on host plants in accordance with his method, have greater viability and attain greater virulence than the bacteria living upon the plant in the ground. Is this state-
798 ment in accordance with present knowledge and accepted scientific opinion?

A. No, there is nothing to support this statement in the present scientific literature.

Q. In lines 8 to 21 of page 3 of the patent it is indicated: "That bacteria may be observed through the

test tube to work on the plant". Is this statement in accordance with present knowledge and accepted scientific opinion?

A. It would be impossible to observe microscopic bacteria through the walls of a test tube on the roots of plants buried in jelly within that test tube.

The objective of a high-powered microscope must be closer to the object being examined. The thickness of the walls would preclude an examination of what these tiny bacteria are doing.

Q. In the same portion of the patent the patentee indicates: "That bacteria which enter the roots but that do not form nodules may aid the plant without any external evidence of their presence being visible."

Is this statement in accordance with present knowledge and scientific opinion?

A. This statement is not in accordance with present knowledge and scientific opinion. It is necessary for
799 the bacteria to affect the root and form nodules before they may benefit the plant.

Q. In lines 91 to 100, on page 3 of this patent, the patentee indicates: "That too many root nodule bacteria may injure the germinating plant".

Is this statement in accordance with present knowledge and accepted scientific opinion?

A. No; the patentee claims the root nodule bacteria actually ate out the contents of pea seeds. The root nodule bacteria are incapable of digesting the materials contained within a pea husk. There is nothing to substantiate this statement.

800 Q. May I now call your attention, Mr. Bond, to the statement occurring at lines 6 to 18, on page 2 of the patent, which reads as follows:

> "Owing to this necessity for employing the proper kind of bacteria for each kind of plant, it has been necessary to maintain many different kinds of stock cultures in the laboratory each containing bacteria adapted for a particular plant. Also it has been necessary first to ascertain from a purchaser, the kind of plant which he intended to inoculate before his order could be filled. And as it is necessary to make up the cultures in distributing packages prior to the opening of the season for which they are to be used, so that orders may be filled without delay, it has been necessary to make a supply of distributing packages of each kind of bacteria."

Do you agree with that statement?

A. The statement is essentially true. There are details in it such as:

"Also it has been necessary first to ascertain from a purchaser, the kind of plant which he in-
801 tended to inoculate."

Of course, none of the commercial inoculant companies find it necessary to check up with their customers to see what they are going to buy, but essentially the statement is true.

Q. Now, does this portion of the specification of this patent which I have just quoted to you recognize the advantages of a composite culture?

A. That portion that has just been quoted recognizes the disadvantage of the single cultures.

Q. But made from the composite culture disclosed in this U.S. Patent?

A. In my opinion commercial products so prepared in accordance with the specification of this patent would not be uniformly satisfactory.

Q. On what do you base that opinion?

A. There are tests in the literature showing the unsatisfactory nature of Earp-Thomas composite Farmogerm culture.

Q. Does this patent teach you how to make a satisfactory composite culture containing only clover and alfalfa?

A. No.

802 Q. Does this patent, in your opinion, contain any teaching which would assist one skilled in the art to produce a successful mixed culture for leguminous plants for field work as distinguished from a single culture?

A. No.

Q. Now, I wish you would direct your attention to Earp-Thomas Patent No. 1,099,121, and will you please state generally what this patent discloses?

A. This patent merely discloses the introduction of the concept of the soil culture to be applied to field—to the soil of the field and not to the seed. It is prepared in accordance to the cultures previously described in the Earp-Thomas patent which we just discussed.

Q. 865,965?

A. Yes.

Q. Does that complete your answer, Mr. Bond?

A. Yes, there is nothing else in this patent, that is essentially for soil culture.

Q. Does this patent contain any teachings which would assist one skilled in the art to produce a successful mixed culture for leguminous plants as distinguished from a single culture?

803 A. No.

Q. Will you now direct your attention to the Bottomley Patent No. 1,106,275? Will you kindly state what bearing, if any, the teachings of this patent have with respect to legume inoculants?

A. This patent is a treatment, as the title indicates, a treatment of peat for manurial and other purposes. It has nothing to do with seed inoculation. It is a mixture of three nitrogen fixing bacteria and root nodule bacteria.

Q. What does this patent disclose, rather generally?

A. It is a fertilizer for manure.

Q. Does this patent contain any teachings which would assist one skilled in the art to produce a successful mixed culture for leguminous plants as distinguished from a single culture for field use?

A. No.

Q. Will you now direct your attention to the Earp-Thomas Patent 1,252,322? To what does this patent relate?

A. This patent relates to humus material containing several different types of bacteria and the culture is coated with material which is alleged to protect the 804 bacteria from the harmful effects of fertilizers.

Q. And does this patent say anything about the use of this product in combination with chemical fertilizers, and I refer you particularly to page 1, lines 95 to 99?

A. Yes, these lines refer to the coating of the culture to protect the bacteria in the culture from the effect of fertilizers and other materials with which the culture was intended to be mixed.

Q. Now, in your opinion, does this patent contain any teachings which would assist one skilled in the art to produce a successful mixed culture for leguminous plants as distinguished from a single culture for field use?

A. No.

Q. I now ask you to take up the Earp-Thomas Patent No. 1,309,723, and generally what does this patent disclose and what is it directed to?

A. This patent is essentially a fertilizer containing phosphate rock. The patentee claims that the different types of bacteria present in this fertilizer will reduce the raw phosphate rock to soluble form and therefore make it available to the plant.

Q. Is that statement in accordance with present scientific opinion?

805 A. Most bacteria are very ineffective for reducing phosphate rock to soluble form and the root nodule bacteria in particular would have no effect whatsoever on the phosphate rock.

Q. In your opinion as a man skilled in the art, does this patent contain any teachings which would assist one skilled in the art to produce a successful mixed culture—

A. No, sir.

Q. (Continuing:)— for leguminous plants as distinguished from a single culture?

A. No.

Q. I now want to refer you to the last prior art patent that the defendant is relying on, namely, the Thomas Franklin Manns Patent No. 1,320,701. Can you just give first a general statement as to what this patent purports to disclose?

A. This patent purports to disclose actually two products, the first product— both of which are prepared from peat humus. The first product is claimed to be a bacteria compost for a rich compost containing all the known beneficial soil bacteria.

The second product is a reinforced inoculated or
806 bacterized peat.

The first product is prepared by mixing peat, phosphate, lime, slag, wood ashes, dried blood and molasses and well inoculated soil, moistening the mixture and composting it aerobically for two weeks. The well inoculated soil used to inoculate the mixture is a mixture of soil proven to contain Azotobacter, nitrofying, cellulose destroying, ammoniafying and legume bacteria.

Q. Now, this first product is referred to at page 1, line 41, is it?

A. That is correct.

Q. And the second product at page 3, line 49?

A. That is right.

Q. Now, referring to this first product, are the bacteria contained in a base having a low nutrient value?

The Witness: No, the author states on page 1, line 1[illegible]

"I have discovered that peat, muck, manure, weed compost or other organic material can be trans-
807 formed into a fertilizer containing an accumulation of nitrate nitrogen by bacterial action and a humus content having a high stimulative influence on plant life and possessing great value as a plant food, a soil improver and fertilizer, by reinforcing or adding to the organic matter, phosphorous in the form of basic slag,"

and several other mineral and organic materials. The latter part of my statement is not a quotation from the patent.

Q. I now direct your attention to that portion of the patent on page 2 contained in lines 65 to 96, and ask you whether you agree with the statement insofar as it relates to the grouping of root nodule bacteria into six main cross-inoculation groups?

A. In general the statement is correct.

Q. And is there anything in the Manns Patent and particularly in the excerpt which I have just referred you to that indicates any recognition by the patentee as to the possibilities of inhibition?

A. No, there is no indication of the possibility or existence of inhibition. In fact there is no indication
808 of the recognition that different strains of root nodule bacteria might even vary in their efficiency with respect to fixing nitrogen.

Q. And is there any indication that the patentee does not appreciate the possibility of inhibition, and I refer you particularly to page 2 of the patent, lines 66 to 69.

A. No, the patentee uses well inoculated soil upon which is grown the particular legume for which the inoculation is introduced. A well inoculated soil taken from a field may have hundreds of different strains in it, some of them good strains, some of them fair strains and some of them poor strains, and there would be no way of knowing how efficient or how effective strains from soil dug out of a field might be.

Q. Now, without going into too much detail, can you explain briefly how the patentee proposed to prepare his compost containing all of the beneficial soil bacteria?

A. Well, the compost is prepared in accordance with the mixture indicated on page 2, starting at line 18. This mixture is moistened, stirred and allowed to incubate

for a period of approximately two weeks, I believe
809 it is stated.

The product is examined from time to time, and when the bacteria has reached a certain growth, the patentee concluded the product was ready for use.

Q. In preparing this so-called bacterial compost, does the patentee initially add a large number of each type of bacteria to it?

A. No, the addition of 25 pounds of a mixture of well inoculated soil containing all of these—containing bacteria for all of these cross-inoculation groups—

I am sorry I didn't follow it. I have forgotten what I am talking about. Will you state the question, please?

Mr. Thiess: Will you read it, please?

(The record as above recorded was read by the reporter.)

The Witness: (Continuing:)—adding 25 pounds of well inoculated soil containing bacteria for all the cross-inoculation groups would scarcely be adding a sufficient number of each of these different species to thoroughly inoculate the seeds without additional growth in the compost, and when this additional growth takes place there is no certainty that one specie will not over-
810 grow another.

There is no way to be sure that when you depend upon the growth of the bacteria in this compost that there will be sufficient numbers of any one of all the six groups to thoroughly inoculate the seed for which the product is recommended.

Mr. Thiess: Q. Then, as I understand you, this patentee depends upon the growth of the different species of bacteria in the compost to get the desired number of bacteria of each species in the final product, is that correct?

A. That is correct.

Q. Now, on page 2 of this patent, line 115, the patentee states that such inoculated compost is "allowed to undergo aerobic composting for two weeks to three months," which means he allows the organisms to grow in the moistened mix for that period of time, is that correct?

A. That is correct.

Q. Now, do you know whether bacteria compost of the type disclosed in the patent were eve used commercially?

811 A. The compost so prepared in accordance with all Dr. Manns' testimony was used to prepare Alphano inoculant.

Q. Now, are you familiar with any tests that have been made on the bacterial compost disclosed in the Manns Patent, and I refer you particularly to Bulletin 115, which has been introduced as Defendant's Exhibit 16.

A. Yes, I am.

Q. And have you studied and analyzed the test results reported in this bulletin?

A. Yes, I have.

Q. Can you classify these tests into two different groups?

A. Yes. The first portion of the bulletin is devoted to tests with composts in 4-gallon pots. There is a second portion in which a sterilized sand experiment was conducted and the plants were grown in sterilized sand to which some type of an inoculation was added. I presume it was part of the compost that had been prepared previously.

Q. What is your opinion as to the value of the compost tests referred to in the bulletin?

812 A. Well, the compost tests were actually a test comparable to planting the legume plants actually in a seed inoculant. That is, he had the product which was prepared in accordance with the specifications—essentially prepared in accordance with the specifications of the Manns' patent, product one of the Manns patent, and 8,000 gallons of this product was placed in 4-gallon jars, and seeds were planted in these jars, and the results obtained were not significant inasmuch as there were no uninoculated sterile controls.

However, there were a few composts in his series to which no uninoculated soil had been added. However, the percentage of plants in which nodules were observed in the composts prepared with the well inoculated soil is about the same as the percentage of plants with nodules that were in the composts prepared without the well inoculated soil, indicating that the condition of the well inoculated soil with the product did not—so far as the test is concerned, actually did not alter the product in any substantial way.

Q. Will you please discuss the sterile sand experiment?

A. The sterile sand experiment had apparently no—as far as the bulletin states there are no uninoculated sterile controls, and plant 7 which has been referred to shows pictures of the various plants which had been inoculated, but there is no picture of the control. Whether or not the author ran a control I do not know, but if he did not run a control he has no assurance of where these bacteria came from. There is no indication that the seed was sterilized. There is no indication that the water used to water the plants was sterilized. And if the author did have a sterile control there is no indication of it in the bulletin and it is not in his pictures.

Q. Now, does this bulletin and the Manns patent contain any teachings which would assist one skilled in the art to produce a successful mixed culture for leguminous plants as distinguished from a single culture?

A. No.

The Court: Q. Well, what have you to say about this second paragraph on page 25?

A. Page 25? You mean "it has been inferred", that part, "it has been inferred by certain producers of commercial inoculants that the organism of each particular legume requires a culture medium slightly different from that of another, and particularly adapted for the organism in question."

Well, we know that certain groups of the root nodule bacteria grow better on one type of media, whereas another group may grow better on the second type. However, all the groups will grow readily on a given medium if it is properly prepared.

Going on with that further, "that 'the germs for one variety of legumes will not work on any other variety of legume'" is the generally accepted opinion in the art at this time, that is, with respect to cross-inoculation groups. There is an occasional exception where the bacteria from one cross-inoculation group will form nodules on a second, but it is a very rare occurrence, especially in agricultural legumes of commercial importance. It is more common with wild legumes. There may be something to the evolution of organism that has something to do with that. We do not fully understand just w' causes that, but it is a very rare occurrence. I have never run into it and I know of no reported tests where a substantial amount nodulation was obtained, where definitely pure cultures of alfalfa bacteria were put on

red clover plants or on soy bean plants and nodules were formed on those plants.

In the light of recent investigation it is shown that the organisms for different groups of important legumes may be successfully carried in one and the same composts. This particular bulletin shows that several groups, different groups of the legumes have been placed in this compost and he was able to get nodule formation on his plants. That is, inasmuch as we assume that he had sterile controls on which he found no nodules formed. I mean, this is the author's conclusion from his experiments. On the basis that he had sterile controls on which no nodules were formed, it would mean that a compost freshly prepared might have sufficient organisms in it to form nodules on a few of the groups that he tested, for that is all the bulletin shows, and inasmuch as the bulletin does not show any uninoculated controls there is no way of knowing whether the author's conclusions are valid or not.

816 The Court: Where he says it may be successfully carried in one and the same compost.

The Witness: He is referring to the humus mixture.

The Court: Yes, I know what he is referring to there, but does it mean that he has got a combination of cultures there that work on different varieties of these plants?

The Witness: Well, I did not quite understand the whole paragraph. I don't follow exactly what the first part of the paragraph has to do with the second, but I do not believe the author is intending to imply that one organism will inoculate all the different varieties. Now, this is my interpretation of what the author thinks.

The Court: I know, but isn't he telling you there that he has found the composite group will work when used together?

The Witness: That is the conclusion of the author, yes. The validity of that conclusion, based on the data presented in the bulletin, is subject to question, but even assuming it were correct, that is all the farther he has gone. He says you can put these different cultures

817 in the one mixture and get nodules sometimes, and as far as the claims of the mixed culture in the Bond patent are concerned, we go farther than that. We do admit that mixed cultures were in existence prior to 1[illegible] and the newness isn't the mere presence of the

organisms in the mixture, but the introduction of new material is the preparation of mixed culture in such a way, containing selected strains of organisms, so that a maximum job can be done.

There were indications that when these mixtures were made that the efficiency of these individual strains, individual species in that culture, were reduced. The literature indicated that, and the other experiments have shown that, too, and the result is that unless these are carefully selected strains that we know are not—will not inhibit each other, will not reduce their efficiency, that is, will not change from good to poor when you mix them together, is the only way a good commercial mixed product could be made.

Mr. Thiess: Q. And there is no teaching of that 818 in the Manns' patent or in the bulletin?

A. There is nothing about that. It is purely a mixture of the bacteria together. Of course, there is nothing new about that, a mere mixture of the different species of bacteria.

Q. That was done in the garden cultures, wasn't it?

A. That has been done for a long time, yes, and that is all that is indicated there.

Q. Now, Mr. Bond, I would like to ask you this question: You have been accused here with making a false statement deliberately in your patent, and I want to ask you if you deliberately made any statement in your patent that you knew was not true?

A. Absolutely none.

Q. And prior to your investigation of the literature in 1937, did you believe that mixed strains in a culture would inhibit their nitrogen fixing ability?

A. If someone had asked me that prior to my investigation of the literature, I would say that I had no basis for believing that such were true.

Q. But after your investigation of the literature—

A. To me it definitely indicated that the existence of antagonistic strains or inhibitive strains were 819 very prevalent. There was absolutely no indication in the literature that when a mixture was mixed together, that the strains would not be affected; that is, their efficiency would be reduced.

Q. Will you please refer to these pages, 135 and 136, of the publication of Fred, Baldwin, and McCoy; and this, as I understand, refers to the general grouping of

organisms. No, will you just refer to that statement and tell me what this book says there in this quotation on pages 135 and 136?

A. Well, on pages 135 and 136, I presume you are interested in the paragraph starting with "Morthology and flagellation", is that correct? If you want me to tell you what the pertinent part is, I have no objection to doing so. I am trying to find out what part of pages 135 and 136 you want. I can read them all.

Q. You might read those right on.

A. Essentially, looking at the pages, it is referring to two different groups of the root nodule bacteria. They have been classified into two groupings. One of these groups has certain morphological characteristics and
820 certain physiological and cultural characteristics.

The other group varies in those particular characteristics, and in the first group are included the alfalfa, clover, bean,—they are the most prominent, well known organisms that are in that group. They are the fast growing group. They form more mucus, slimy material in the growth. They are also characterized by the formation of what is known as a serum zone in a litmus milk tube. This is a physiological test. And they are also characterized by their merititious coagulation. The other group, on the other hand, is morphotitious in respect to coagulation, does not form a serum zone in litmus milk, is relatively slow growing in comparison. That group includes cow peas, soy bean and lupine.

This discussion on pages 135 and 136, refers to these cultural and morphological groups, which means their shape and size and characteristic, and has nothing to do with mixing them together, because the different species happen—four of the species happen to be fast growing and two or three of the others are slower growing. They put them in these groups. It was easier
821 by the last test to decide what they were and it is merely distinguishing between the two groups. It has nothing whatsoever to do with mixing them together on composite cultures. There is no correlation there at all.

Q. Is there any teaching in these pages about inhibition?

A. No, absolutely none.

Mr. Greer: I think it is fair to Mr. Bond to call attention to why I introduced page 136. I did not in-

troduce page 135 at all, and the only part of page 136 that I wanted to bring to the Court's attention is the sentence in the second full paragraph on that page, reading: "In some cases, the variation between the reaction of known strains of the same Rhizobium is so great that apparent differences between cross-inoculation groups cannot be urged too far."

Mr. Greer: Page 136, in the middle of the page, approximately. It is the second sentence, in the second full paragraph on page 136.

822 Mr. Thiess: Q. Now, will you discuss that statement in connection with the context on that page and the prior page?

A. This statement refers to the characterization of the organisms solely by means of their cultural and physiological characteristics. The best method for distinguishing between, say, an alfalfa species and soy bean species is actually to try them on the plants, but by means of these physiological and cultural tests you can frequently distinguish between the soy bean bacteria and the alfalfa bacteria; but occasionally, as it says here, in some cases the variation between the reaction of known strains of the same Rhizobium is so great that apparent differences between cross-inoculation groups cannot be urged too far.

Essentially the authors are stating that the bacteria should not be classified in different species solely on the basis of their cultural characteristics and that further tests should be conducted on the plants. That is essentially what they are referring to here in that particular statement.

Mr. Thiess: That is all.

823 Mr. Greer: No cross-examination.

Mr. Rathburn: There are two more minor short admissions that I would like to read into the record, your honor, along with the responses. The request No. 73, the statement, rather, which plaintiff requested the defendant to admit:

"Prior to the Bond patent, in suit 2,220,812, the Albert Dickinson Company, Chicago, Illinois, had not manufactured and sold any mixed culture of two or more species of root nodule bacteria other than garden culture."

The answer by defendant is:

"For response to request for admission No. 73, the

defendant is advised and believes that the Albert Dickinson Company, of Chicago, Illinois, prior to the date of the application or issue of the Bond patent in suit, had not manufactured and sold any mixed culture of two or more strains or species of root nodule bacteria other than the 'garden size package' culture."

Request No. 74:

"Prior to the Bond patent in suit, No. 2,220,812, Agricultural Laboratories, Inc., Columbus, Ohio, had
824 not manufactured and sold any mixed culture of two or more species of root nodule bacteria other than garden culture."

Defendant's response:

"The response to request for admission No. 74 is the same as that of the response to request for admission No. 73."

Mr. Thiess: Plaintiff rests.

Mr. Greer: Defendant rests.

Whereupon both sides rest.

UNITED STATES CIRCUIT COURT OF APPEALS

For the Seventh Circuit.

I, Kenneth J. Carrick, Clerk of the United States Circuit Court of Appeals for the Seventh Circuit, do hereby certify that the foregoing printed pages contain a true copy of Volume 1 of the Printed Record, being one of 2 Volumes of said Printed Record filed on October 19, 1946, in:

Cause No. 9040-41.

Kalo Inoculant Company,
Plaintiff-Appellant,

vs.

Funk Brothers Seed Company,
Defendant-Appellee;

and

Kalo Inoculant Company,
Plaintiff-Appellee,

vs.

Funk Brothers Seed Company,
Defendant-Appellant,

as the same remains upon the files and records of the United States Circuit Court of Appeals for the Seventh Circuit.

In Testimony Whereof I hereunto subscribe my name and affix the seal of said United States Circuit Court of Appeals for the Seventh Circuit, at the City of Chicago, this 1st day of August, A. D. 1947.

Kenneth J. Carrick,
(Seal) *Clerk of the United States Circuit Court of Appeals for the Seventh Circuit.*

CLERK'S COPY.

Vol. II

TRANSCRIPT OF RECORD

(Pages 369 to 840)

Supreme Court of the United States

OCTOBER TERM, 1947

No. 280

FUNK BROTHERS SEED COMPANY, PETITIONER,

vs.

KALO INOCULANT COMPANY

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SEVENTH CIRCUIT

PETITION FOR CERTIORARI FILED AUGUST 19, 1947.

CERTIORARI GRANTED OCTOBER 13, 1947.

IN THE

Supreme Court of the United States

OCTOBER TERM, 1946.

No.

FUNK BROTHERS SEED COMPANY,

Petitioner,

vs.

KALO INOCULANT COMPANY,

Respondent.

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SEVENTH CIRCUIT.

INDEX.

Index to printed record of proceedings in U. S. District Court i
Clerk's Certificate to Vol. I of printed record of proceedings in U. S. District Court 368a
Clerk's Certificate to Vol. II of printed record of proceedings in U. S. District Court 813

INDEX TO PROCEEDINGS IN COURT OF APPEALS.

Placita 815
Order taking cause under advisement, entered May 8, 1947 816
Opinion by Lindley, J., filed June 12, 1947 817
Judgment No. 9040, entered June 12, 1947 834
Judgment No. 9041, entered June 12, 1947 835
Petition to stay Mandate, filed June 27, 1947 836
Order staying Mandate, entered June 27, 1947 837
Clerk's Certificate 839

Order allowing certiorari 840

VOL. II pp. 369 to 811

TRANSCRIPT OF RECORD

IN THE

United States Circuit Court of Appeals

FOR THE SEVENTH CIRCUIT

KALO INOCULANT COMPANY,
Plaintiff-Appellant,

No. 9040 vs.

FUNK BROTHERS SEED COMPANY,
Defendant-Appellee.

KALO INOCULANT COMPANY,
Plaintiff-Appellee,

No. 9041 vs.

FUNK BROTHERS SEED COMPANY,
Defendant-Appellant.

Appeals from the District Court of the United States for the Southern District of Illinois, Southern Division.

TRANSCRIPT OF RECORD FILED MARCH 4, 1946.
PRINTED RECORD.

INDEX—9040

	PAGE
Placita	1
Complaint, filed Dec. 10, 1943	2
Answer and Counterclaim, filed Jan. 26, 1944	5
Reply to Counterclaim, filed Feb. 14, 1944	13
Amended Answer, filed Oct. 28, 1944	15
Order setting cause for trial, entered Apr. 30, 1945	17
Order resetting cause for trial, entered May 14, 1945	17
Stipulation re: Patents, etc., filed June 25, 1945	18
Stipulation re: Claims, etc., filed June 25, 1945	19

REPORT OF PROCEEDINGS.

Plaintiff's Interrogatories	27

WITNESSES FOR PLAINTIFF.

Testimony of:

Bond, Varley Sherman	34, 353
Burris, Robert H.	345
Curie, Irvin Harold	21
Lusk, Myron E.	138
Umbreit, Wayne William	338

WITNESSES FOR DEFENDANT.

Testimony of:

Curie, Irvin Harold	153
Erdman, Lewis W.	220
Hofer, Alvin William	300
Leonard, Lewis Thompson	289
Manns, Dr. Thomas Franklin	243

PLAINTIFF'S EXHIBITS.

NO.		Introduced in Evidence at page	Reproduced at page
1.	Package of "Legume-Aid" inoculant for clover and alfalfa	22	369
2.	Bond Patent No. 2,200,532	26	769
3.	Chart headed "Source of Stock Strains"	68	371
4.	Chart headed "Nodulation Test"	68	374
5.	Chart headed "Efficiency Test for Nitrogen Fixation"	68	375
6.	Chart headed "Importance of Efficiency Tests"	68	377
7.	Chart headed "Preparation of Humus Type Culture"	68	379
8.	Can of "Uni-Culture" Humus of Plaintiff	68	
9.	Can of "Uni-Culture" inoculant for clover, alfalfa and soy beans	68	
10.	Chart entitled "Effect of Inhibition in Mixed Culture"	68	381
11.	Translation of Praktische Blatter, headed "On Mutual Retardation and Favoring Between Nodule Bacteria," by Max Kronberger	68	383
12.	Pamphlet entitled; "Division of Bacteriology, Progress Report of The Dominion Agricultural Bacteriologist," by A. G. Lockhead for years 1931, 1932 and 1933	68	395
13.	Pages of book entitled, "Root Nodule Bacteria and Leguminous Plants"	68	397
14.	Photograph headed "Clover, 40 Plants Each Group"	91	402
15.	Photograph headed "Soy Beans, 8 Plants Each Group"	91	404
16.	Chart entitled "Reduction in Yield of Red Clover Due to Inhibition"	94	406

NO.		Introduced in Evidence at page	Reproduced at page
17.	Letter July 29, 1938, Lusk to Matchette	146	408
18.	Letter July 29, 1938, Hofer to Bond...	326	410
19.	Letter July 19, 1938, Hofer to Bond...	327	412
20.	Title page and pages 14 and 15 of 1938 Lockhead publication	327	416
21.	Letter May 18, 1945, Hofer to Conn...	335	422
22.	Translation of article by Prof. Dr. Gerlach and R. Vogel, entitled "Observations on the Action of Hiltner's Pure Cultures for Legumes".....	338	423

DEFENDANT'S EXHIBITS.

1.	"Culture Chart and 1932 Price List" as to moist powder humogerm, a humus base legume inoculant made with farmogerm bacteria	241	437
2.	Package labeled "Inoculation, McQueen's Inoculator, Good for Sweet Peas—Lupines, Garden Peas and Beans	241	
3.	Photograph showing front and back of Package—Defendant's Exhibit No. 2..	241	440
4.	Advertisement and Wholesale Price List effective July 15, 1937—Season 1937-1938, of McQueen's, Inc.....	241	442
5.	Summary headed "Efficiency of Clover Bacteria as Affected by Alfalfa Bacteria, dated Oct. 27, 1944.....	337	446
6.	A—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 202," heading below "Plus 12 Strains Alfalfa Bacteria"	337	447
6.	B—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A1," heading below "Plus 12 Strains Alfalfa Bacteria"..	337	449

NO.		Introduced in Evidence at page	Reproduced at page
6.	C—Photograph showing two rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A2," heading below "Plus 12 Strains Alfalfa Bacteria"	337	451
6.	D—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A3," heading below "Plus 12 Strains Alfalfa Bacteria"	337	453
6.	E—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A4," heading below "Plus 12 Strains Alfalfa Bacteria"	337	455
6.	F—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A5," heading below "Plus 12 Strains Alfalfa Bacteria"	337	457
6.	G—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2A6," heading below "Plus 12 Strains Alfalfa Bacteria"	337	459
6.	H—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2B1," heading below "Plus 12 Strains Alfalfa Bacteria"	337	461
6.	I—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2B2," heading below "Plus 12 Strains Alfalfa Bacteria"	337	463

NO.		Introduced in Evidence at page	Reproduced at page
6.	J—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2B3," heading below "Plus 12 Strains Alfalfa Bacteria"	337	465
6.	K—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "Clover Bacteria 2B4," heading below "Plus 12 Strains Alfalfa Bacteria"	337	467
6.	L—Photograph showing 2 rows of 5 jars each with plants, heading above top row "Clover," heading between rows "12 Strains Clover Bacteria," heading below "Plus 12 Strains Alfalfa Bacteria"	337	469
7.	Document entitled "The Effect of Nodule Bacteria Rhizobium Meliloti on the Activity of Clover Nodule Bacteria Rhizobium Trifolii," by I. H. Curie	338	471
8.	Document entitled "Bond Patent, No. 2,200,532; Nitrogen Fixed per 10 Plants Clover, etc."	241	473
9.	Letter June 30, 1941, Curie to Bachelor	241	475
10.	Advertisement "Nitragen Facts That Bear Great Weight," dated 1923, and showing prices of the Nitragen Company, Inc., of Milwaukee, Wis., giving miscellaneous cuts, price cuts and other information	241	476
11.	A—Photograph of can bearing the wording "Nobbe-Hiltner Process, Nitragen for Garden Peas, Garden Beans, Sweet Peas and Lupines, Good until December 31, 1935"	241	478
11.	B—Photograph of can showing the wording "The Original Legume Inoculator, Nitragen," etc.	241	478

NO.		Introduced in Evidence at page	Reproduced at page
11.	C—Photograph of can showing the word "Directions" and the wording "Use Only for Seeds Stated on Top Label, etc."	241	480
11.	D—Photograph of can, side view, showing the word "Caution," etc. and the word "Guarantee," etc.	241	480
12.	Can labeled "Nitragen," of The Nitragen Company, Inc., Milwaukee	241	
13.	Report of Lewis W. Erdman, headed "Does One Species of Legume Bacteria Produce an Inhibitory Effect on Another Species within the same Culture?"	241	483
14.	A—Photograph showing 3 rows, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "Alfalfa Bacteria Strain 3DOa1," bottom row headed "Alfalfa Bacteria Strain 3DOa1 Plus 5 Strains Red Clover Bacteria"	241	488
14.	B—Photograph showing 3 row, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "Alfalfa Bacteria Strain 3DOa7," bottom row headed "Alfalfa Bacteria Strain 3DOa7 Plus 5 Strains Red Clover Bacteria"	241	490
14.	C—Photograph showing 3 rows, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "Alfalfa Bacteria Strain 3DOa10," bottom row headed "Alfalfa Bacteria Strain 3DOa10 Plus 5 Strains Red Clover Bacteria"	241	492
14.	D—Photograph showing 3 rows, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "Alfalfa Bacteria Strain 3DOa12, bottom row headed "Alfalfa Bacteria Strain 3DOa12 Plus 5 Strains Red Clover Bacteria"	241	494

NO.		Introduced in Evidence at page	Reproduced at page
14.	E—Photograph showing 3 rows, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "Alfalfa Bacteria Strain 3DOa15," bottom row headed "Alfalfa Bacteria Strain 3DOa15 Plus 5 Strains Red Clover Bacteria"	241	496
14.	F—Photograph showing 3 rows, 5 jars each row, top row headed "Alfalfa" "Controls," middle row headed "5 Strains Alfalfa Bacteria," bottom row headed "5 Strains Alfalfa Bacteria Plus 5 Strains Red Clover Bacteria"	241	498
15.	A—Two sheets entitled "Experiment No. 1—Crimson Clover, Sept. 22 to Jan. 7, 1938 and Crimson Clover-Trifolium incarnatum, Oct. 19, 1939 to Jan. 20, 1940"	241	500
15.	B—Two sheets entitled "Red Clover Trifolium pratense, Oct. 18, 1939 to Jan. 15, 1940, and Experiment No. 1—Red Clover, Sept. 21 to Dec. 14, 1937"	241	501
15.	C—Two sheets entitled Table 3: "Nitrogen Fixation by Twenty Strains of R. Meliloti on Alfalfa Burr Clover and Sweet Clover, Oct. 15 to Dec. 10, 1938, and Table 3"	241	503
15.	D—Two sheets entitled Table 5: "Nitrogen Fixation by Twenty Strains of R. Meliloti on Alfalfa, Burr Clover and Fenugreek, Feb. 10 to April 17, 1939, and Table 5"	241	505
16.	Document entitled Bulletin No. 115, Delaware College Agricultural Experiment Station; "A Preliminary Report on Muck Humus as a Fertilizer and Carrier of Beneficial Soil Bacteria" by Manns and Coheen, dated December 1916	249	508
17.	Booklet entitled "The Alphano Book," published by Alphano Humus Co., New York City	256	564

NO.		Introduced in Evidence at page	Reproduced at page
18.	Bottle containing sample Humus used during experiments of Thomas E. Manns in connection with Alphano product composites in research work previous to date of publication of Bulletin No. 115 (Deft's Exhibit No. 16)	257	
19.	Bulletin 377 of January 1923, entitled "Results of Seed and Legume Inoculant Inspection for 1922," of the New Jersey Agricultural Experiment Station, Department of Seed Analysis (Portion of)	259	620
20.	Book of Patents (See List of Patents)	259	
21.	Document entitled "Circular 703, Department of Agriculture"	290	628
22.	Pamphlet entitled "Nitrogen from the Air Converted Into Food for Plants by Ferguson's Nitrogen Bacteria"	294	636
23.	Article entitled "The Effects of Non-beneficial Nodule Bacteria on Austrian Winter Pea," by Leonard and Dodson	295	644
24.	Article entitled "Somes Tests with Soilgro," by Leonard	295	647
25.	A—Letter May 22, 1945, Lockhead to Hofer	303	655
25.	B—Letter June 7, 1945, Conn to Hofer	303	656
25.	C—Letter June 8, 1945, Reid to Hofer	303	657
25.	D—Letter May 29, 1945, Albrecht to Hofer	303	658
25.	E—Letter May 26, 1945, Sears to Hofer	303	659
25.	F—Letter May 21, 1945, Waksman to Hofer	303	660
25.	G—Letter May 23, 1945, Vandecaveye to Hofer	303	661
25.	H—Letter May 23, 1945, Hansen to Hofer	303	662
26.	Photograph showing rows of pots containing plants, the front row bearing the following numbers on individual pots: 3, 4, 2, 0, 1-5, .5, 1, 5, 4, 1-5, 0, 3, 2 and 1	306	664

No.		Introduced in Evidence at page	Reproduced at page
27.	Photograph showing pots with plants, the following numbers appearing in front of the pots: 1, 1-5, 0, 3 and 2....	306	666
28.	Photograph showing plants in pots...	306	668
29.	Table bearing the heading: Clover Plants—Weights Expressed in grams; and with columns a, b, c, d, e, f, g and h on the left-hand side of the table; and the columns designated as Total, Average, % N, Total N% 8 Pots, and Total on the right-hand side of the table....	309	670
30.	Report headed "Comparison of Types of Culture Based Upon Tests made in New York State.....	313	672
31.	Report headed "Yield of Lima Beans from Two Types of Inoculants".....	317	673
32.	Agricultural Bulletin 292 of November, 1934, of Department of Agriculture and Markets of State of New York entitled: "Report of Analysis of Samples of Seed Collected in New York State July 1, 1933 to June 30, 1944. Also report on Legume Inoculant Tests Made in 1934" (Portion of).....	319	674
33.	Article designated as Circular No. 137 (Revised), New York State Agricultural Experiment Station, Geneva, N. Y., "Soil Inoculant Service," by Conn and Hofer, dated January 1, 1934	321	680
34.	File Wrapper of Patent No. 2,200,532.	336	684
35.	Page 114 of book entitled "Root Nodule Bacteria and Leguminous Plants" by Fred, Baldwin and McCoy.....	337	740
36.	Page 136 of book entitled "Root Nodule Bacteria and Leguminous Plants" by Fred, Baldwin and McCoy.....	337	742

PAGE

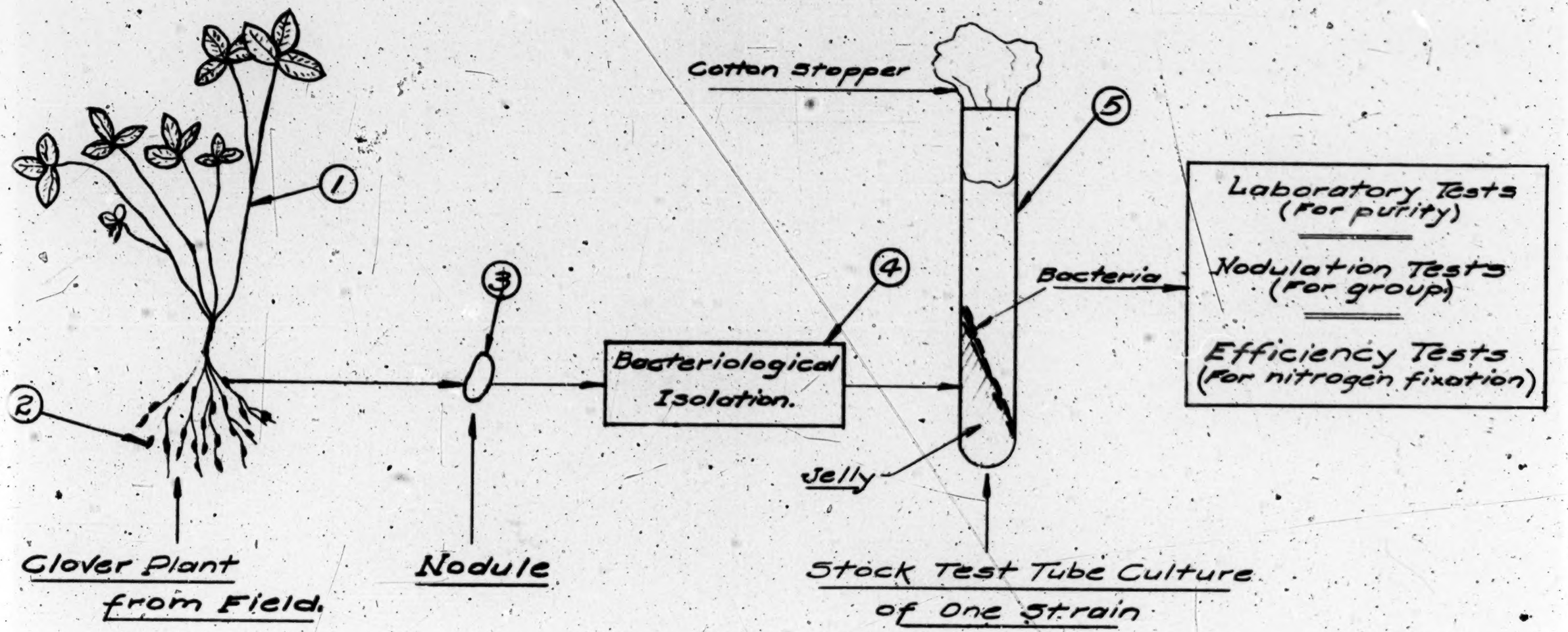
Memorandum of Holdings, filed Sept. 27, 1945..... 744
Findings of Fact, etc., filed Oct. 10, 1945..... 745
Conclusions of Law..... 752
Judgment entered Oct. 10, 1945..... 754
Notice of Appeal by Kalo, filed Jan. 2, 1946 755
Statement of Points..... 756
Bond for Costs..... 757
Notice of Appeal by Funk, filed Jan. 8, 1946..... 759
Statement of Points..... 760
Cost Bond 764
Stipulation extending time to file Transcript..... 765
Stipulation re: Transcript of Testimony..... 767
Stipulated Designation of Record..... 768
Clerk's Certificate 810

UNITED STATES LETTERS PATENT.

No. 2,200,532—V. S. Bond, May 14, 1940..... 770
No. 865,965—G. H. Earp-Thomas, Sept. 10, 1907.... 780
No. 1,099,121—G. H. Earp-Thomas, June 2, 1914..... 786
No. 1,106,275—W. B. Bottomley, Aug. 4, 1914..... 790
No. 1,252,332—G. H. Earp-Thomas, Jan. 1, 1918..... 792
No. 1,309,723—G. H. Earp-Thomas, July 15, 1919.... 798
No. 1,320,701—Thomas F. Manns, Nov. 4, 1919..... 804

LEGUME-AID
ALFALFA & CLOVER COMBINATION
LEGUME-AID
PLFS. EX. 1 IDEN.
LEGUME-AID
IS USED TO
INCREASE YIELDS
IMPROVE QUALITY
AND BUILD UP
SOIL FERTILITY
IMPORTANT
This carton contains a mixture of two different kinds, or groups, of nodule bacteria.
(1) The Alfalfa Group
For Alfalfa, Sweet Clover, Hubam, Southern Bur Clover, and Black Medic.
(2) The Clover Group
For Red, Alsike, White, Mammoth, Ladino, Hop, and Crimson Clover.
Particularly recommended for inoculating mixtures of Alfalfa and Clover seed, or EACH separately.
INOCULANT
ANOTHER STEP AHEAD
DIRECTIONS
GUARANTEE
Inoculate
ALL LEGUME SEED WITH LEGUME-AID
EVERY YEAR
PRODUCED, TESTED AND GUARANTEED BY
AGRICULTURAL LABORATORIES INC.
CARTON SIZE NO. 1
369-370

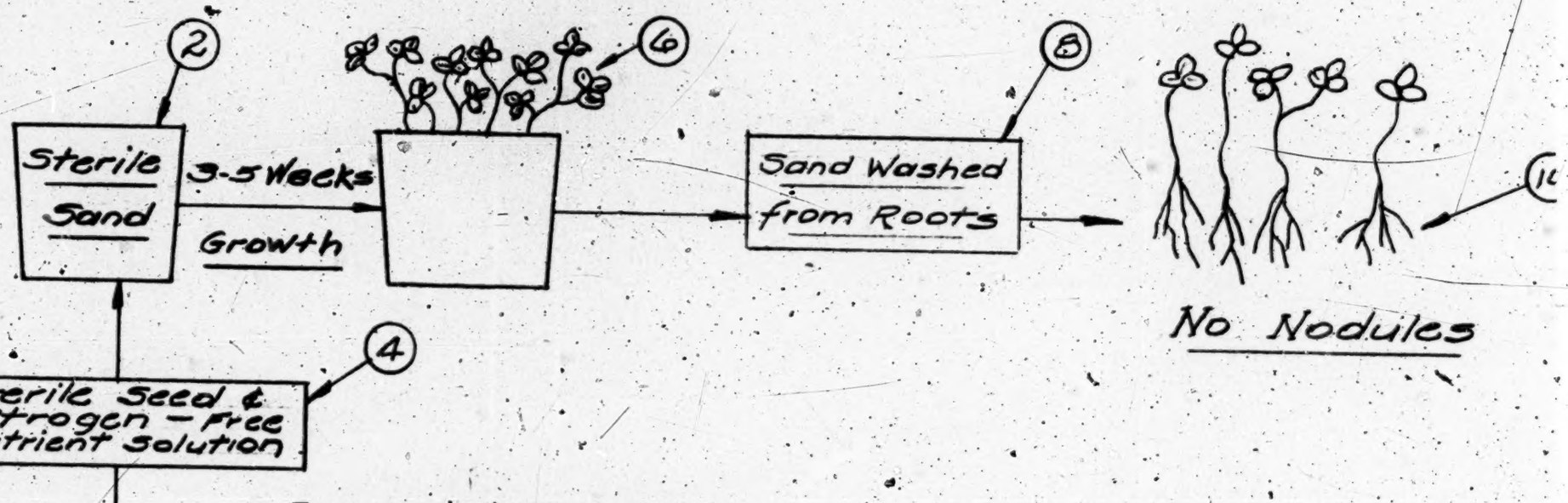
Source of Stock Strains



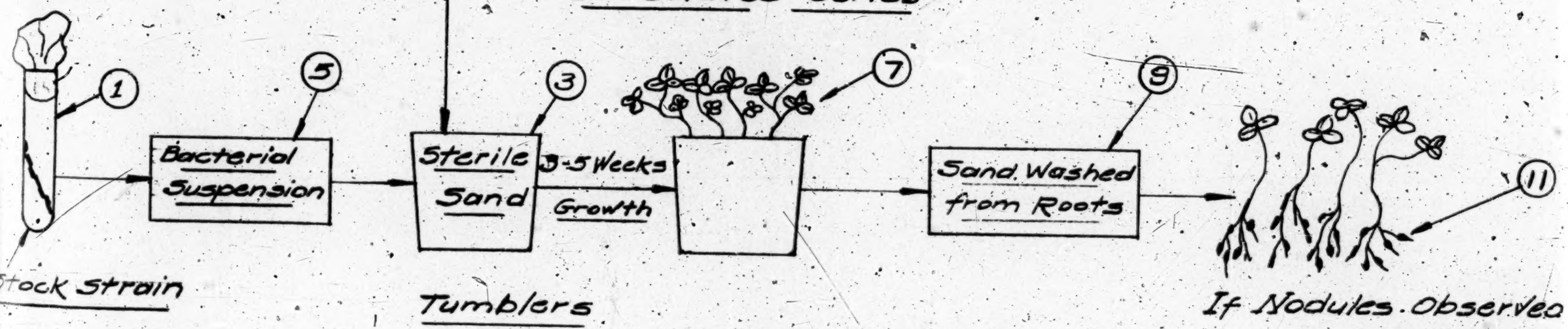
PLFS. EX. 3 IDEN.

Nodulation Test

Uninoculated Control Series

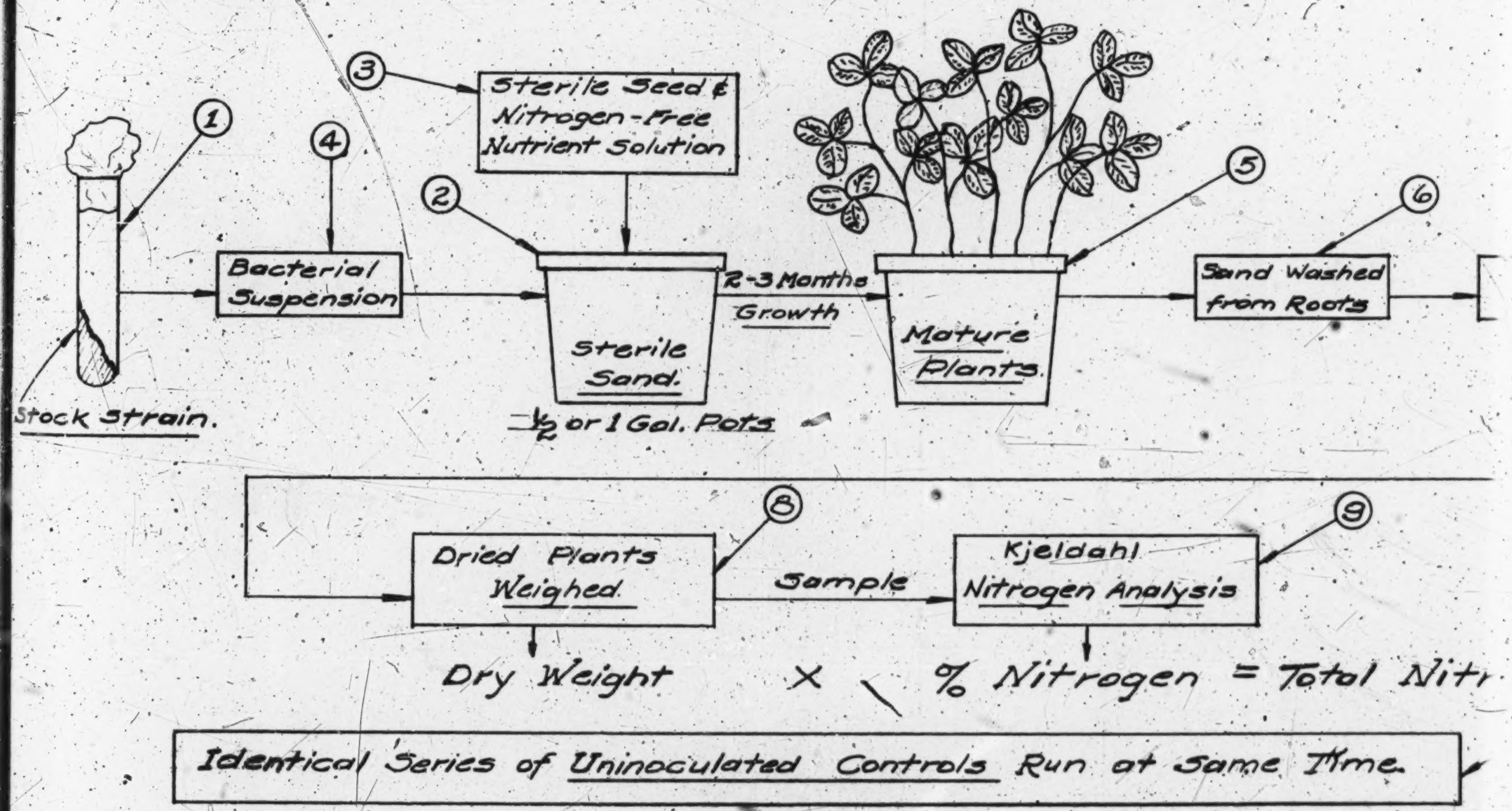


Inoculated Series



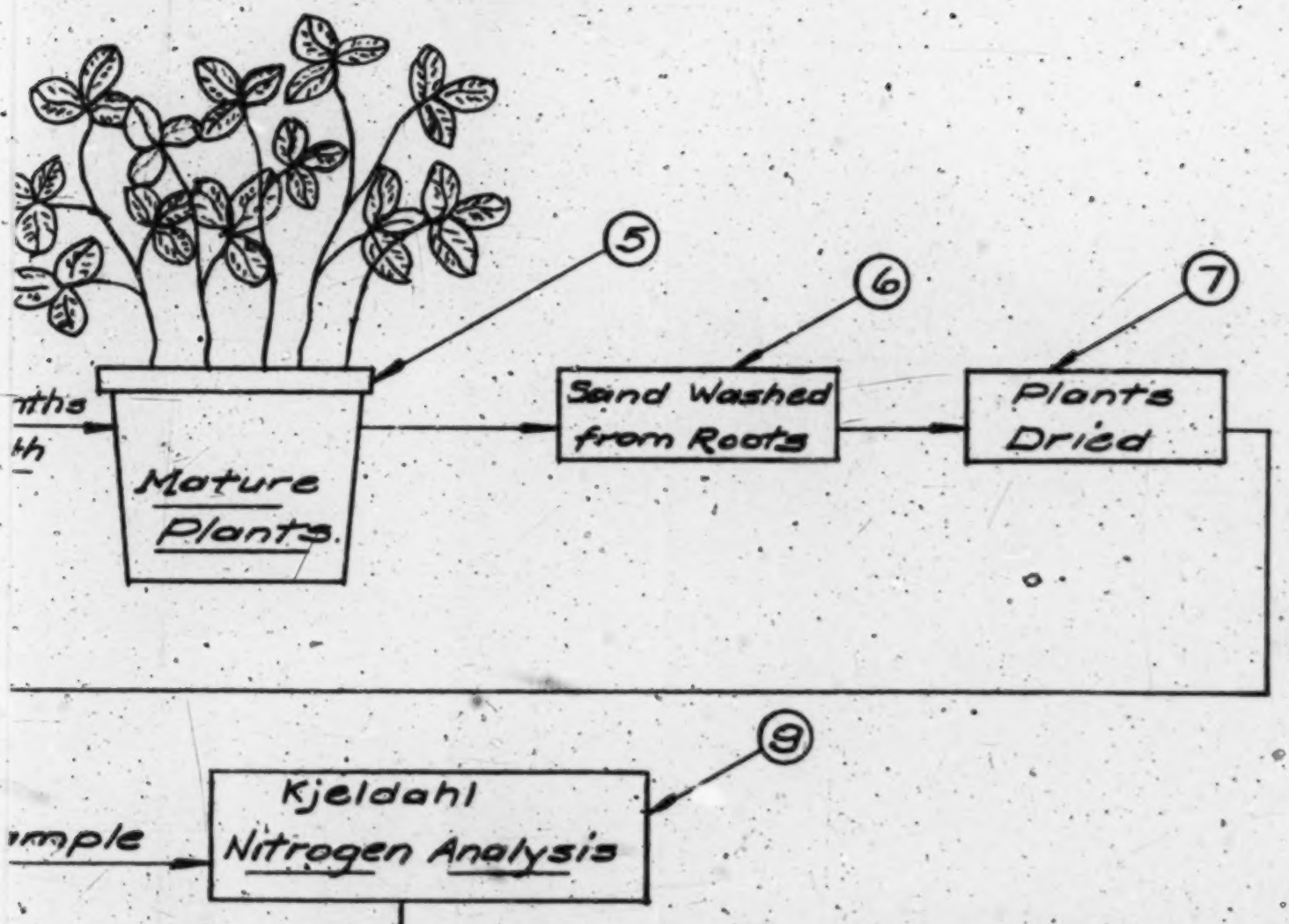
PLFS. EX. 4 IDEN.

"Efficiency" Test for Nitrogen Fixation

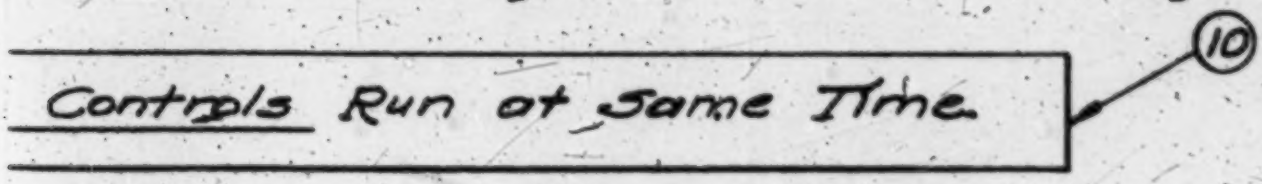


PLFS. EX. 5 IDEN.

trogen Fixation



% Nitrogen = Total Nitrogen

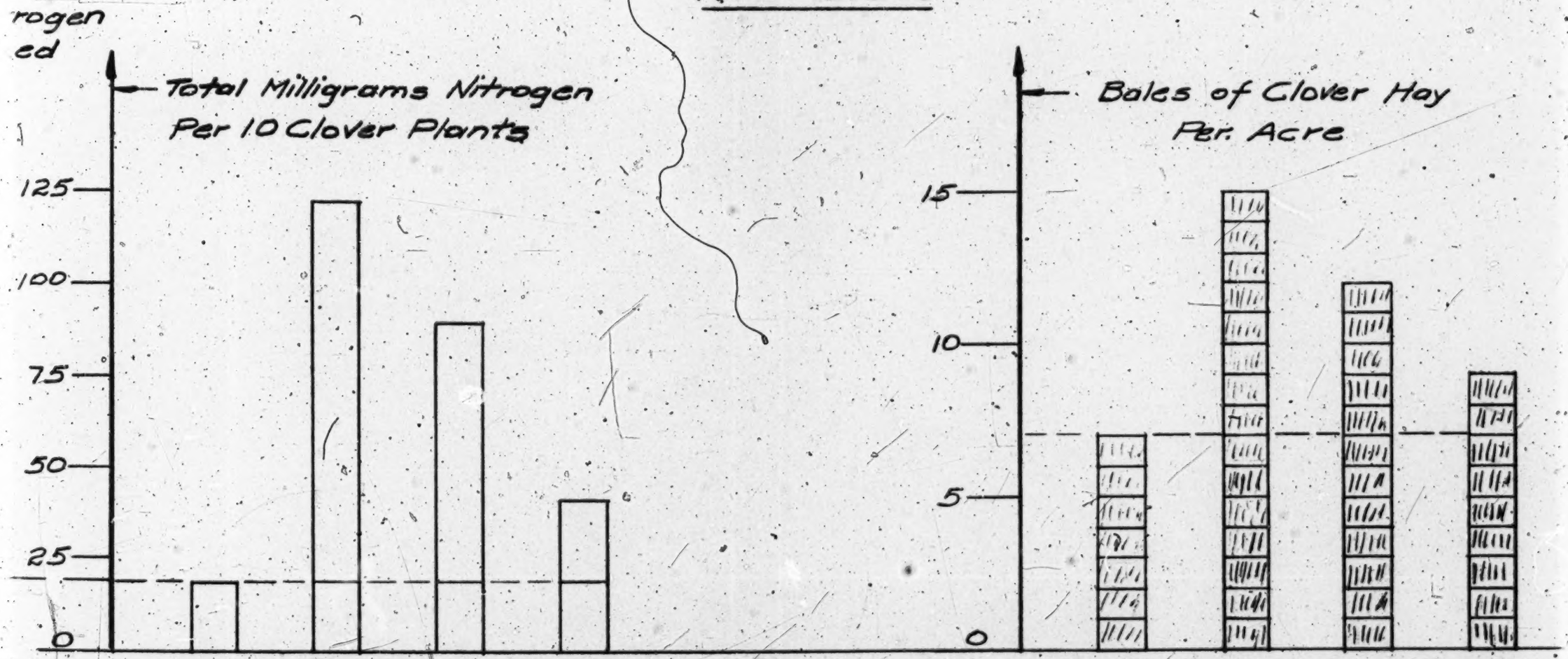


n Inoculated – Total Nitrogen Control

PLFS. EX. 5 IDEN.

Importance of "Efficiency" Tests

Red Clover

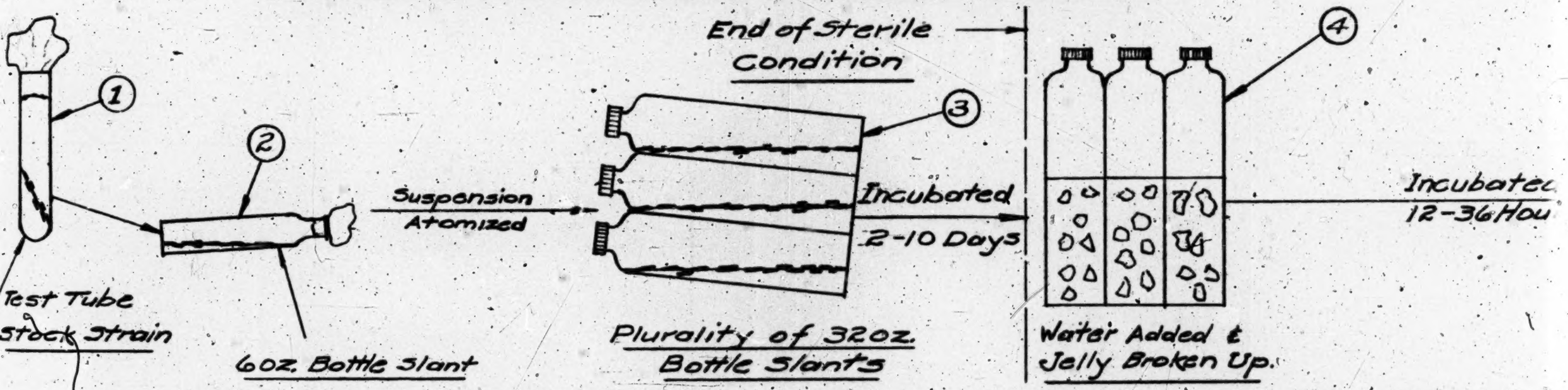


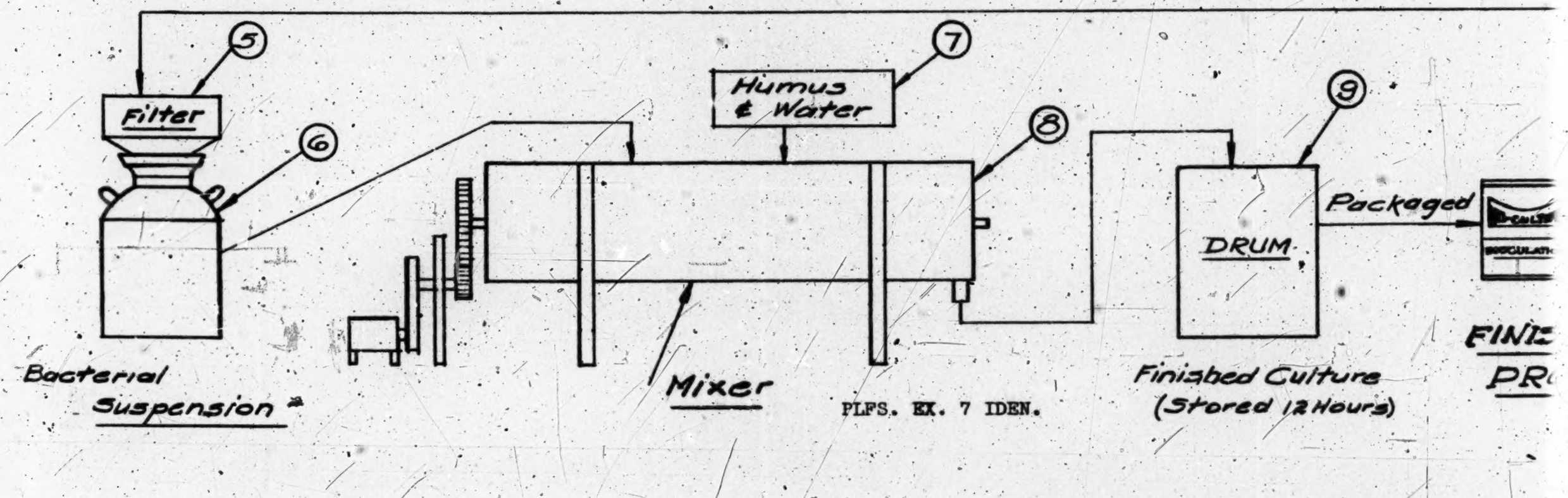
Greenhouse Efficiency Tests

Field Results

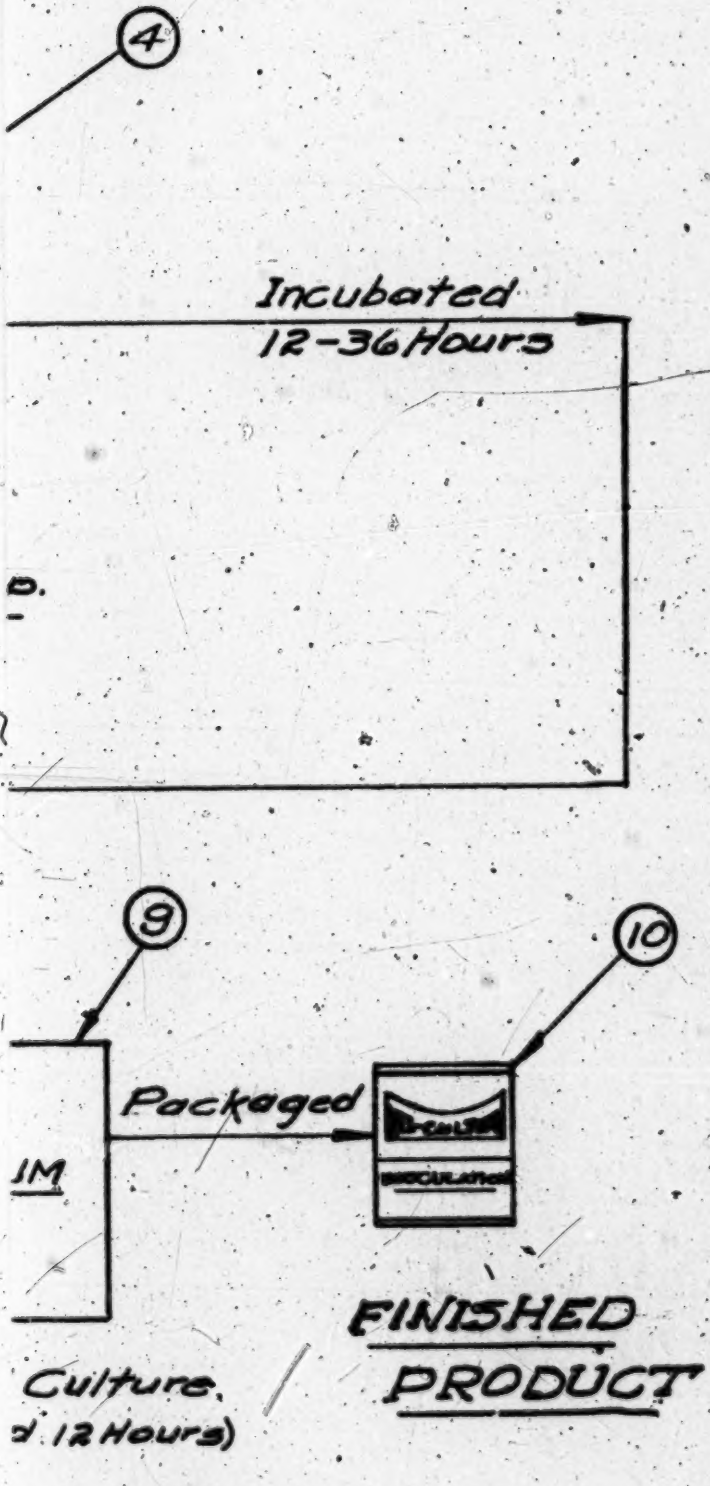
PLFS. EX. 6 IDEN.

Preparation of Humus Type Culture.





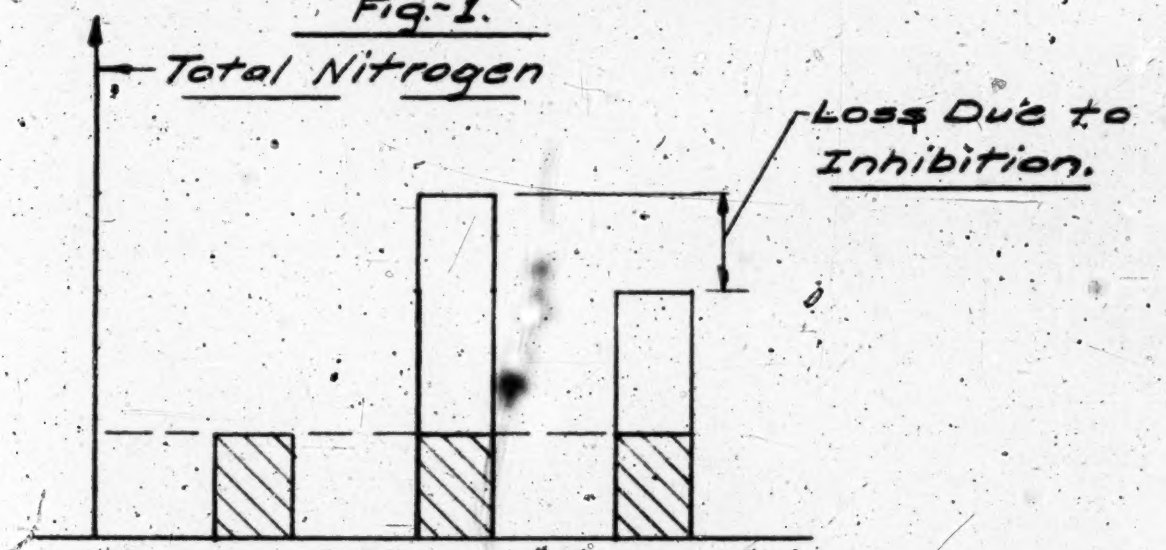
PLFS. EX. 7 IDEN.


4
Incubated
12-36 Hours
D.
9
10
Packaged
IM
FINISHED
PRODUCT
Culture.
d 12 Hours)

Effect of Inhibition in Mixed Culture.

Inhibitive Strain of Bacteria.

Fig.-1.



Non-Inhibitive Strain of Bacteria.

Fig.-2.

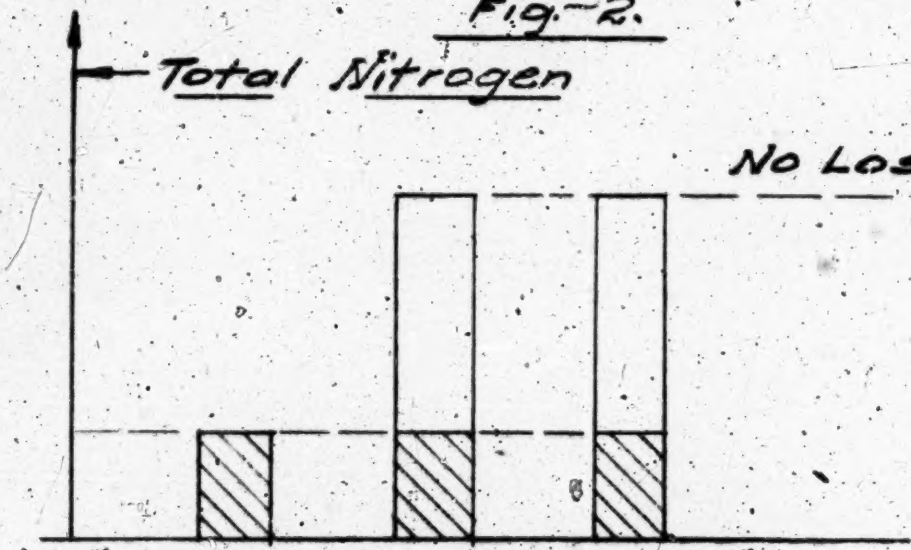


Fig.-3.

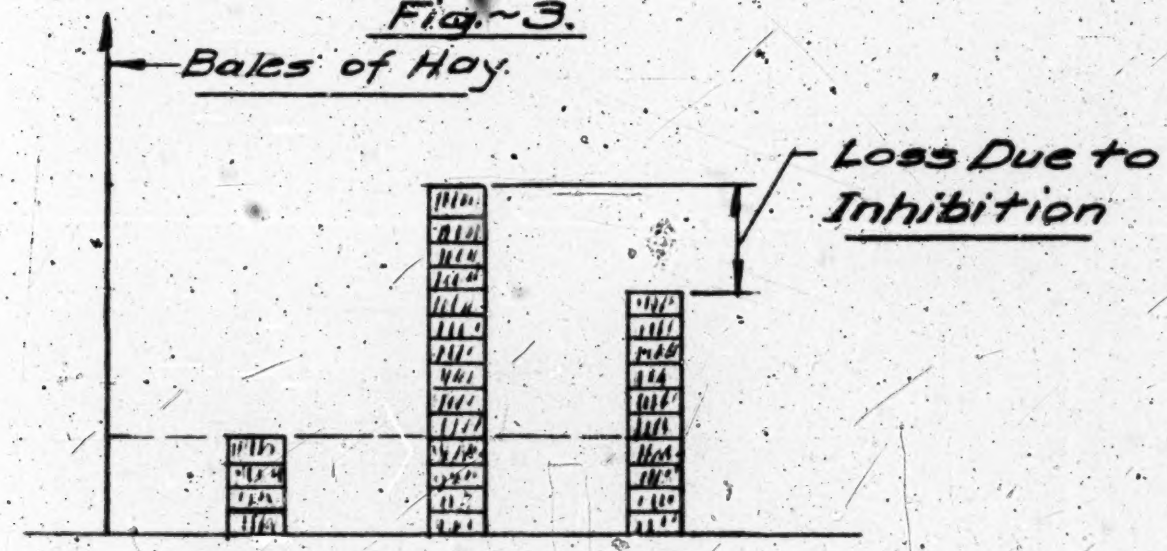
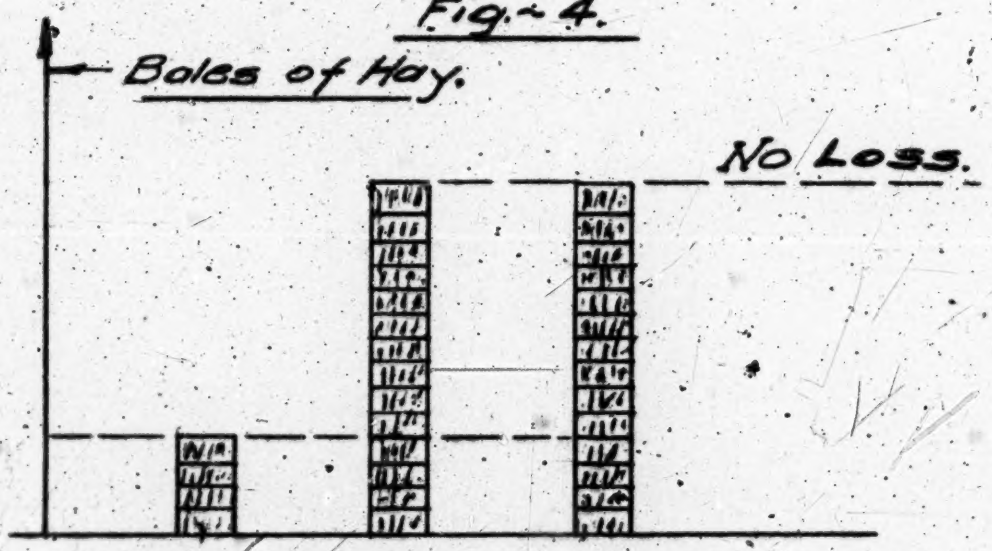


Fig.-4.



PLFS. EX. 10 IDEN.

PLAINTIFF'S EXHIBIT 11.

832 IN THE

DISTRICT COURT OF THE UNITED STATES

SOUTHERN DISTRICT OF ILLINOIS

SOUTHERN DIVISION

KALO INOCULANT COMPANY, a corporation, Plaintiff, vs. FUNK BROTHERS SEED COMPANY, a corporation, Defendant.	Civil Action No. Q-62 Patent Infringement Suit Bond Patent No. 2,200,532

STIPULATED TRANSLATION.

833 IT IS STIPULATED AND AGREED by and between the parties hereto, the Honorable Court consenting, subject to correction should error appear, that the following is a true and correct translation from the German of an article published in *Praktische Blätter für Pflanzenbau und Pflanzenschutz*, Vol. XIV, No. 7 (1936-1937):

On Mutual Retardation and Favoring Between Nodule Bacteria

By Max Kronberger; Bavarian Agricultural Institute for Plant Culture and Plant Protection, Munich, Germany.

The important role which is played by the nodule bacteria in the nitrogen nourishment of the leguminous plants does not require any further proof. Of particular interest, however is the fact that between the individual species of nodule bacteria there subsists mutual injurious and favoring influences which are closely connected with the nitrogen economy and hence also with the growth of the plants. Our previous knowledge on this subject is principally based on the older researches of Gerlach and Vogel and Heinze and L. Hiltner. Gerlach and Vogel (1) were the first to show that the nodule development of inoculated lupines, and, in connection therewith, also the yield of green mass, was only medium when lupine, and

the best when serradella, had been sown as the preceding crop. If, conversely, the inoculated lupines were cultivated after soya beans, then the effect of the inoculation was found to be almost zero. Heinze (2) has established the fact that lupines following after peas remained
free of nodules while after serradella they exhibited
834 a copious covering of nodules and gave twice as much
nitrogen as those cultivated after peas. In the work of L. Hiltner (3) there is found the valuable datum that the intolerability between serradella and red clover is also at least partly due to unfavorable (antagonistic) mutual relations between the nodule bacteria of serradella and red clay. He sums up the results of his research as follows:

". . . It is thus clearly seen that the red-clover bacteria exert an influence on the development of serradella which is even injurious, that is, as was established by microscopic examination, because while these bacteria are attracted by the serradella roots and come to cover them densely they do not penetrate into them but only to a certain extent block the way of serradella bacteria which may come afterward or may be present in small numbers in the ground, in that, as it seems, they neutralize the attracting substance of the roots.".

The present research also constitutes a contribution to this important finding. Through this research it has been sought to ascertain, on the one hand, the action of the nodule bacteria of red clover under the influence of other varieties of nodule bacteria of legumes on red clover, and, on the other hand, the action of the latter types of bacteria under the influence of nodule bacteria of red clover on the particular legumes.

It was our intention only to deal with those types which can be regarded, with respect to their biological behavior toward symbiotic nitrogen-fixing, as particularly characteristic, and which are characteristic of those legumes following which red clover frequently turns out to be a
failure (4). For these reasons we selected the nodule
835 bacteria of the horse bean, pea, vetch, alfalfa, yellow
lupine and serradella.

The arrangements for obtaining the inoculating cultures necessary for the carrying out of the experiments were carried out on June 5, 1935, in such a way that each of the fresh cultures of the nodules bacteria to be tested

(including that of red clover) was brought in the form of a strip onto the sterile nutrient-agar plate, both by itself and at the same time with the particular breed of nodule bacterium concerned, in the form of parallel lines, as uniformly as possible. The composition of the nutrient medium was the same as that employed by the Agricultural Institute for the production of legume inoculating material. The inoculating cultures, in the form of three applications, were left standing for 21 days at room temperature before being used in the experiments. During this period there was not observed any retardation in growth in any case. Both the pure cultures and the mixed cultures exhibited a good growth. The experimental plan can be seen from the recapitulation.

As the experimental vessels there served clay pots, each of which was filled with 2500 grams of Hohenbocka quartz sand and 1000 grams of humus, lime-bearing, unfertilized earth. The fertilization of each of the pots consisted of 2 grams of 40% potash salt and 4 grams of superphosphate. After being filled, the vessels were covered with a germ-free wadding, and kept in the autoclave for 25 minutes at an absolute pressure of 1 atm. superatmospheric. The purpose of the sterilization was the killing of any nodule bacteria that might be present in the soil material employed. The preparation of the seed to be sown
836 consisted in each case of a cauterization with 1% sublimate solution. The duration of the cauterization amounted to 15 minutes. The sowing occurred on June 26th with the employment in each case of 4 times 25 grains per vessel for the red clover, serradella and alfalfa, and 3 times 2 grains with the peas, vetch, horse bean and yellow lupine. The inoculation was carried out immediately after the swelling of the seed in such a way that in each case there was brought into the ground 30 cc of the pure or mixed culture concerned mixed with 150 cc of sterile tap water and with 0.5 gram of thereto added milk powder. In doing so the germinating plant, which has originally been covered by the wadding, was only exposed far enough to allow the stalk to come out. Watering occurred in the course of vegetation under the employment of distilled water. Of the rest of the vegetation notes the following may be mentioned:

Stand on August 6th

1. Red Clover.

The best stand was, as was to be expected, exhibited by the plants which had been inoculated with their own variety of bacterium. The effect of this inoculation as compared with the other series is expressed in the darker leaf color as well as in the higher growth. Under the addition of nodule bacteria of horse bean as well as of vetch to the nodule bacteria of red clover there is observed a good to very good growth. Good, although somewhat weaker, is the action of the red clover alfalfa inoculating-material. The color of the plants may be described as the normal green. Less pronounced is the effect of the mixed culture of nodule bacteria of red clover plus peas. In both cases the growth of the clover is
837 somewhat retarded and its leaves are considerably lighter in color. Obviously more difficult is the intake of nitrogen of the plants inoculated with the nodule bacteria of red clover and serradella. They exhibit in general nearly the same behavior as "uninoculated" plants, are of a light-green leaf color and a low growth.

2. Horse Beans

The best and highest are the horse beans which have been inoculated with their own variety of bacteria. They excel in a green-dark green leaf color. While the addition of red-clover nodule-bacteria to their own variety of culture exhibits a somewhat smaller nitrogen action, its superiority to the uninoculated series is nevertheless clearly expressed in the somewhat darker green of the leaves.

3. Peas

Also here the inoculation with the peas' own culture is the most favorable. The leaf color of the plants owing to the nitrogen supply may be described as dark green. Not very favorable to the growth and the stand of the peas is the addition of red-clover nodule-bacteria to the peas' own culture. Nevertheless the total impression is better than that of the uninoculated series.

4. Vetch

A certain worsening of the inoculating action is un-

doubtedly present in the case of the mixed culture consisting of nodule bacteria of red clover and vetch. The stand of the plants is not as good as with their own inoculating culture, and they are considerably lower in growth. The uninoculated vetches are particularly distinguished by their light-green leaf-color and their small increase in growth.

838 *5. Alfalfa*

The inoculation of alfalfa with its own variety of culture is able to supply its nitrogen requirements. The plants are of an outstandingly fresh-green color. Less favorable is the action of inoculation with the mixed culture of nodule bacteria of red clover and alfalfa. Light-green leaves and low growth characterize the uninoculated plants.

6. Yellow Lupine

The development of the lupines treated with the red clover-lupine inoculating-material is definitely better than that of the uninoculated plants, even though no sharply-defined difference has as yet appeared. Conversely, the inoculation with bacteria of its own kind exhibits a perceptible result, which can be recognized by the lively green of the leaves as well as by the great increase in growth.

7. Serradella

As with lupine so also with this species of legume a considerable favoring of growth is only present in the case of inoculation with its own form of bacteria. Also the color of the leaves is already green-darkgreen. Less favorable, however, is the mixed culture of nodule bacteria of red clover plus serradella. The most unfavorable impression is that of the uninoculated series.

August 27th

The superiority of the cultures of their own kind is more sharply pronounced in all of the series. The plants exhibit the most vigorous development, dark-green leaf-colors, and copious new growth. While the leguines inoculated with the mixed cultures clearly exhibit a nodule action, there are observed, on the whole, within the indi-

vidual comparative series, differences similar to those of August 6th.

839 *September 8th*

A considerable favoring of lupine is now also present with the mixed culture, although not to the same extent as with its own culture.

The harvesting in such case was now carried out on a date at which the development of the green mass had proceeded farthest. On September 2nd there were harvested horse bean, peas, vetch and serradella. The first cutting of the red clover and of the alfalfa occurred on October 7th and the second on November 16th. On the same day the lupine was also harvested.

The plants gave, in a mean of 3 comparative vessels, the following values in dry weight (see recapitulation on page 207 (of original German text)).

841

	grams						greater (plus) or less (minus) yield compared with	
	first cutting			second cutting		total	uninoculated	plant's own culture
							%	%
serradella								
uninoculated	3.80	plus-or-minus	0.12	plus-or-minus	...		plus	....
inoculated with serradella nodule bacteria	8.67	"	0.26	.....	...		" 128.16	....
ditto plus red clover nodule bacteria	6.67	"	0.66	.....	...		" 75.53	—23.07
horse bean								
uninoculated	7.83	"	1.26	.....	...		....	....
inoculated with horse-bean nodule-bacteria	20.33	"	1.86	.....	...		" 159.64	....
ditto plus red clover nodule-bacteria	19.00	"	0.40	.....	...		" 142.66	— 6.54
peas								
uninoculated	6.83	"	0.33	.....	...		....	....
inoculated with peas nodule bacteria	13.66	"	0.53	.....	...		" 100.00	....
ditto plus red clover nodule bacteria	10.17	"	0.53	.....	...		" 48.90	—25.55
vetch								
uninoculated	5.27	"	0.26	.....	...		....	....
inoculated with vetch nodule bacteria	7.50	"	0.20	.....	...		" 45.07	....
ditto plus red clover nodule bacteria	6.00	"	0.20	.....	...		" 18.6[illegible]	—20.00

390

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842

yellow lupine								
uninoculated	9.00	plus-or-minus	0.40	.....	...	plus	....	
inoculated with lupine nodule bacteria	24.17	"	0.23	.....	...	" 168.55	....	
ditto plus red clover nodule bacteria	21.33	"	1.26	.....	...	" 137.00	—11.75	

Plaintiff's Exhibit 11

843 As can be seen from the values listed in the accompanying recapitulation all of the plants inoculated with their own bacterium culture exhibit a considerable increase in yield. But neither has the mixed culture in any case remained without action as compared with the "uninoculated" plants.

Examining now to what extent the inoculation effect of the red-clover nodule-bacteria is influenced by the nodule bacteria of the vetch, it is seen that no considerable decrease in the clover yield has resulted therefrom. The decrease in the harvest only amounts to 4.97%. A somewhat greater decrease in the harvest, that is, only 5.40% was brought about through the addition of horse-bean nodule-bacteria. However, also here the results are only slightly worse than those of the plant's own culture. While neither of these two differences is, as already mentioned, particularly appreciable, they must nevertheless be taken into account. Already more clearly expressed is the decrease in harvest with the red clover-alfalfa inoculation-culture, in which the deficit brought about through the addition of the alfalfa nodule bacteria has risen to 9.25%. A greater decrease in the harvest value is due to the addition of the peas nodule bacteria, in that there is here found a deficit of 16.98%. A still more unfavorable effect occurred through the mutual influence between the red-clover and the lupine nodule-bacteria, which, with a decreased yield of 19.55%, occupies the second-last place. Under the influence of the nodule bacteria of serradella, finally, the nitrogen-fixing action of the red-clover nodule-bacteria was by far the least, the loss in harvest amounting to 33.91%.

844 Moreover, in the attempt to establish to what extent the inoculation action of foreign nodule-bacteria cultures under the influence of the red-clover nodule-bacteria is expressed on the harvest of the various legumes, there are also found greater or less increments. The least reactive were the nodule bacteria of the horse bean. Here the decrease in harvest as compared with that of the plant's own type of culture amounts to 6.54%. Next come the nodule bacteria of yellow lupine. With it the decrease in harvested material has already risen to 11.75%. This is true to even a greater degree of the nodule bacteria of vetch, whose nitrogen-accumulating ability has already suffered a loss of 20%. In comparing with each other

the results determined for alfalfa there is noted a deficit of as much as 21.54%. Still worse results were brought about through the addition of red-clover nodule-bacteria to the nodule bacteria of serradella, the yield of the latter dropping 23.07% therethrough. By far the most pronounced, finally, was the retarding action of the foreign culture with peas, in which the loss in harvest brought about therethrough amounts to 25.55%.

In considering the cause of the depression in the nitrogen-fixing ability of the native culture through a foreign culture the first thing that comes to mind is a greater or less withdrawal of nutrient by the accompanying organism. This view is not, however, in the least indicated by the result of our experiments in this direction. It was found, that is, that, upon the reinoculation of red clover or any of the other legumes which had already developed normally for 3 weeks, the growth of the red-clover nodule-bacteria continued to proceed well, even if not so well as on the control bed of the same age.
845 It must, however, be noted in this connection that in the nutrient soil which had previously served for the culture of serradella nodule bacteria, the red clover nodule bacteria started considerably more slowly. The reinoculation of the nutrient soil never occurred in any case until after the removal of the bacteria layer followed by sterilization thereof. Accordingly, it may here be assumed that it is obviously less the nutrient withdrawal than the effect of the by-products of the metabolism of the added type of nodule bacteria which has exerted the decisive influence on the nitrogen-fixing ability of each of the particular native culture concerned. Finally, the circumstance that the nitrogen-fixing ability is influenced through the presence of the one and the other type more and less favorably respectively, would seem definitely to be due more to the difference in the nature than to the difference in the quantity of the products of metabolism of the various types of nodule bacteria tested.

The present work thus again shows that the nodule bacteria of various kinds of legumes do not remain uninfluenced. Particularly from the results determined for red clover there can be seen the greater or less unfavorable influence occurring therethrough on the nitrogen-accumulating ability of red-clover nodule-bacteria and hence also on the yield of clover itself. However, the results

	grams							greater (plus) or less (minus) yield compared with	
	first cutting			second cutting			total	uninoculated	plant's own culture
								%	%
red clover									
uninoculated	13.33	plus-or-minus	0.53	2.27	plus-or-minus	0.18	15.60	....	....
inoculated with red-clover nodule-bacteria	21.83	"	0.66	3.03	"	0.10	24.86	plus 59.35	....
ditto plus peas nodule-bacteria	18.17	"	0.53	2.47	"	0.21	20.64	" 32.31	—16.98
ditto plus horse beans nodule-bacteria	20.67	"	1.26	2.87	"	0.41	23.54	" 50.89	— 5.40
ditto plus vetch nodule-bacteria	20.67	"	1.13	2.97	"	0.30	23.64	" 51.54	— 4.97
ditto plus alfalfa nodule-bacteria	19.83	"	0.23	2.73	"	0.18	22.56	" 44.62	— 9.25
ditto plus serradella nodule-bacteria	14.50	"	1.16	1.93	"	0.09	16.43	" 5.32	—33.91
ditto plus lupine nodule-bacteria	17.67	"	0.53	2.33	"	0.06	20.00	" 28.20	—19.55
alfalfa									
uninoculated	3.33	"	0.18	0.27	"	0.05	3.60	....	....
inoculated with alfalfa nodule bacteria	8.33	"	0.53	1.23	"	0.10	9.56	" 165.55	....
ditto plus red clover nodule bacteria	6.50	"	0.20	1.00	"	0.20	7.50	" 108.33	—21.54

Plaintiff's Exhibit 11

389

also show how important it is to give careful thought to the selection of the place of clover in the sequence of crops following legumes. And not the least important fact that can be seen from these experiments is that it would be a great mistake to use a universal inoculation material for the various types of legumes. This would never give the same increase in yield as the employment of the particular culture, indigenous to the plant.

846 *Bibliography*

(1) Gerlach and Vogel, Zentralbl. f. Bakt. (German Central Journal of Bacteriology), 11d, Vol. 20, 1907, pages 66 et seq.

(2) Heinze, Land. Jahrbuch (German Agricultural Yearbook), 38, 1910, page 340.

(3) L. Hiltner, Jahrb. d. Dtsch. Landw. Gesselschaft (Yearbook of German Agricultural Society), 23, 1908, page 300.

(4) J. Weigert and H. Weizel, Prkt. Blätter für Pflanzenbau und Pflanzenschutz (German Practical Leaves for Plant Culture and Plant Protection), XII, 1934-1935 page 243.

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854 PLAINTIFF'S EXHIBIT 12.

DOMINION OF CANADA

DEPARTMENT OF AGRICULTURE

DOMINION EXPERIMENTAL FARMS

DIVISION OF BACTERIOLOGY

PROGRESS REPORT OF THE DOMINION AGRICULTURAL BACTERIOLOGIST

A. G. Lochhead, B.A., M.Sc., Ph. D.

FOR THE YEARS 1931, 1932 AND 1933

Published by authority of the Hon. Robert Weir, Minister of Agriculture, Ottawa, 1934.

855 pasteurized milk in the vat and the same milk after bottling. In addition, surprise samples were taken from time to time to check on the methods employed by the milkers. Results were reported to the Division of Animal Husbandry, from which Division we have received constant co-operation in all our dairy bacteriological investigations.

SOIL BACTERIOLOGY

LEGUME CULTURE DISTRIBUTION

The distribution of cultures for the inoculation of legume seed to Canadian farmers was continued during the years 1931-33. The distribution of "nitro-cultures" is maintained for educational and experimental purposes, sufficient culture for the treatment of 60 pounds of legume seed being sent free to any farmer on the understanding that the user report the results. Our object is therefore (a) to encourage the more widespread practice of seed inoculation and (b) to accumulate data on the practical results of seed treatment under field conditions. During the years under review the numbers of cultures distributed were respectively 2,561, 6,143 and 7,557. The increases noted in 1932 and 1933 were largely due to our co-operation in the scheme of seed loans to farmers of the Prairie Provinces, whereby cultures sufficient to treat the legume seed distributed by Government aid were provided.

By means of reports returned by farmers using cultures, the Division has been accumulating information on the practical benefits accruing from inoculation in the opinion of the farmers themselves who are the ultimate judges of the value of any farm practice. Out of 1,799 reports so far received, 1,403 or 78 per cent indicated a benefit due to inoculation (81 per cent where crops were grown for the first time). In a large proportion of cases where no benefit was noted the treated and untreated crops grew equally well, indicating not a failure of the culture, but rather that the soil was already supplied with the proper strain of bacteria. On the other hand, the information from our reports supports the view that re-inoculation may be of value. The addition of a "good" strain of bacteria, of high nitrogen-fixing capacity or better suited to the soil type, rather than the mere presence of nodule-forming bacteria in the soil, is probably a factor of importance in such cases.

Examination of Miscellaneous Inoculants

During the triennial period a number of legume inoculants appearing on the market were examined at the request of the Seed Branch, Department of Agriculture. The tests undertaken consisted in estimating the numbers of organisms appearing on Ashby's agar, while in addition greenhouse tests were made of the ability of the culture to produce nodules on the appropriate legume plants when applied as directed. Seeds were sown in sterile sand to which was added plant food minus nitrogen with controls of uninoculated seed and of seed inoculated with a pure culture of *Rhizobium* corresponding to that of the inoculant.

While most of the cultures were capable of inducing nodule formation on the appropriate legumes, the results indicated a superiority of the older method, whereby the seed is moistened when the culture is applied, over the dry inoculation method in which the culture, in the form of a finely divided powder is simply mixed dry with the seed. Furthermore cultures containing bacteria for treating legumes of different cross-inoculating groups were unsatisfactory. Where two strains of *Rhizobium* are mixed in a single culture there is the probability of one strain being suppressed, and it is therefore recommended that an inoculant contain bacteria of but one cross-inoculation group.

856 PLAINTIFF'S EXHIBIT 13.

ROOT NODULE BACTERIA AND LEGUMINOUS PLANTS

BY

Edwin Broun Fred
Ira Lawrence Baldwin
Elizabeth McCoy

MADISON
1932

244 University of Wisconsin Studies

857 *Farmogerm culture.* In 1905, Earp-Thomas applied for a patent relating to the growth and distribution of root nodule bacteria and in 1906 secured such a patent (United States Letters Patent No. 816,850). According to the patentee, "The process essentially consists of growing the bacteria in corked and sealed vessels by a nitrogen-free medium for a given period until the organisms reach a stage of exalted virulence." Since that time a number of other patents have been granted him; Nos. 865,965 in 1907; 1,099,121 in 1914; 1,137,388 in 1915; 1,252,332 in 1918; 1,309,723 in 1919 contain further claims and modifications of his process. As in the patent of George T. Moore, United States Letters Patent No. 755,519, 1904, much emphasis is placed on the fact that in the Earp-Thomas culture the organisms are propagated in a nitrogen-free or, as stated in Patent No. 816,850, *substantially nitrogen-free medium*, consisting of water 2210 cc., wood ashes 14 gm., agar 26 gm., and maltose 35 gm.

The claims of these patents might lead one to suppose that the idea of selecting "virulent" organisms originated with Earp-Thomas; however, a mere glance at the literature reveals the fact that Nobbe and Hiltner,

1896c and d; Moore, 1904; and Kellerman and Robinson, 1906; as well as a number of others, had long since realized the value of selecting highly active cultures.

Some idea of the device suggested by Earp-Thomas for permitting the passage of air to cultures, may be gained from a description of his container. In United States Letters Patent No. 1,137,388, of April, 1915, he claimed "A container comprising a closed receptacle, a conduit tube connecting the atmosphere within the receptacle with the atmosphere external to the receptacle and having its inner end reduced and curved circularly and ending and open to the interior of the receptacle at a point removed from the walls of the receptacle, and a plug of fibrous material in the conduit tube."

In 1914 Earp-Thomas proposed the use of sterilized soil for the propagation and distribution of the nodule cultures and also suggested the value of adding other forms of soil bacteria. A later invention, 1918, suggested the use of humus material, inoculated with the desired bacteria, and coated with agar or some protective material. It was claimed that the coating of the particles to which the bacteria are adhering prevents contamination and protects these bacteria from the harmful action of such agents as fertilizers, acids, etc. The granules of peat coated with agar and bacteria may also be mixed with lime, and thus it is possible to inoculate and lime the soil in one operation. According to Manns and Goheen, 1916, Earp-Thomas, 1921 and 1922, and others, humus alone or properly reinforced with nutrient salts offers a very favorable medium for nodule bacteria.

Composite culture. The desire to have one culture for several crops has led to the preparation of the so-called "dual purpose" or "universal culture," Bredemann, 1912, and Vogel, 1917. In some such preparations, rhizobia of only two or three cross-inoculation groups are included, while in others the makers have gone to the extreme of mixing representatives of all of the more common cross-inoculation groups. Although this method may bring about fair nodule formation, the results are variable. The writers feel that composite cultures offer few advantages and certainly many disadvantages. Perhaps the only justification for this mixing of strains is in the case of the small-size garden culture. Because

of the limited amount of seed to be sown, it may be
858 desirable to have one culture containing the organisms for such crops as beans and peas and thus to reduce the cost of inoculation.

Crushed nodule culture. Remy, 1902, attributed the partial failure of Nitragin to an inherent weakness of the culture itself and not to external factors. In order to secure the best results from inoculation, he suggested the use of fresh crushed nodules instead of the pure laboratory cultures. The results of his experimental work clearly demonstrated the superiority of the crushed nodule method of inoculation. Since the report of Remy, Makrinoff, 1913, and others have used cultures prepared directly from nodules, but have found no indication that this type of culture is better than that prepared in accordance with sound bacteriological methods. For example, Ferguson, 1906, at the Virginia Agricultural Experiment Station, sent out cultures for leguminous crops prepared by seeding a suitable medium with a fresh, washed, and crushed nodule taken from the roots of the particular variety of plant to be treated. Undoubtedly such a procedure offers a simple means of preparing cultures; however, there can be no guaranty that the organisms are in a high state of activity and are in any sense superior to the pure cultures kept under regular laboratory conditions. It is needless to say that the Remy method has not found wide favor. Hiltner, 1902, answered Remy's criticism of cultures grown in the laboratory and showed that the nodule organisms do not lose their efficiency as soon as they are removed from the host, but may be grown for years without degeneration if kept on a suitable medium.

Christensen, 1914 and 1916, compared the value of pure culture and crushed nodules for the inoculation of alfalfa. He obtained the best results from the use of the pure culture, although the differences were not great. Because of the perishable nature of the crushed nodule preparations, he maintained that such a method is useless except under local conditions.

Alinit and mixed cultures. From time to time there appear on the market bacterial preparations for use with non-leguminous plants or in some cases for use

with both the Leguminosae and Gramineae. Generally it is claimed by the manufacturer that these cultures intensify the beneficial bacterial processes of the soil, thus bringing about a gain in the available nitrogen of the soil and consequently an increase in the growth of the higher plants.

Caron as early as 1895 reported an increase in yield of non-leguminous plants from the use of pure cultures of an aerobic bacterium. The process of cultivating this organism known as *Bacillus ellenbachensis alpha* was patented by Caron in 1901. The culture was widely exploited under the trade name of "Alinit," and extravagant claims were made concerning its favorable effect on higher plants. Needless to say, the results of careful field and pot tests failed completely to support the claims of the inventor and distributor.

Patents for mixed cultures of bacteria which were supposed to greatly favor plant growth were taken out by Bottomley in 1911c and 1914. In 1924 Earp-Thomas was granted a patent relating to the culture of beneficial soil bacteria, rhizobia, azotobacter, sulphur bacteria, and other forms in a medium composed of green-sand marl mixed with organic food and moisture-retaining material. The names of some of these bacterial preparations follow: Nitro-bacterine, Phosphogerm, Sulphogerm, All-Crop-Farmogerm, Nitrobacter Soil Vaccine, Soilgro,

859 early as 1888 Beijerinck; and Haas and Fred, 1919, pointed out that the germination of the seed of Leguminosae may bring about conditions favorable for the growth of rhizobia. In this connection mention should be made of the effect of age on the reaction of seed. Wilson, 1929b, found that in general the older the seeds the more acid the reaction.

WHAT CONSTITUTES A SATISFACTORY CULTURE OF RHIZOBIA

Just 29 years ago Hiltner and Störmer, 1903a, published the results of their exhaustive and painstaking studies concerning the essential points to consider in the preparation of pure cultures of the nodule bacteria. Briefly these factors are:

1. Purity. The culture should be true to name and free from foreign organisms.

2. Physiological state. To retain the physiological efficiency of the bacteria they should be cultivated on a suitable medium. A gelatin medium is unsatisfactory.
3. Virulence. The organisms must be able to enter the plant and multiply, but must not be so virulent that they act as parasites on the host.
4. Nitrogen-fixing power. The culture of rhizobia should be selected on the basis of its ability to aid the host plant.

Since 1903 the use of artificial cultures has developed rapidly. Unfortunately those in charge of the preparation of these cultures have not always made use of the scientific facts as laid down by the early workers in the field. The proper application of the scientific discoveries would no doubt have prevented much of the disappointment and loss from the use of poor cultures.

To the authors, the value of a culture seems to depend in a large measure on at least five factors.

1. Upon the organism. It is essential that the culture of bacteria contain the proper organism to form nodules on the desired host plant. In general, it is desirable to have only the one type of organism in the culture.
2. Upon efficiency of the strain. Select an active strain of the desired organism. Because of the variation between strains in relation to effectiveness, every effort should be made to select strains of the bacteria which are known to be of decided benefit to the host plant, and to keep these tested cultures under conditions which will maintain the organisms in an active state.
3. Upon the number of bacteria. Just how many bacteria are required in order to produce the maximum number of effective nodules is not known. In general an abundance of the bacteria, probably several thousand per seed, produces the best results.
4. Upon age of culture. Old cultures may be low in total number of viable cells and those which are alive are presumably in a weakened condi-

PLFS. EX. 14 IDEN.

CLOVER

UNINOCULATED STRAIN: 13-19 (UNMIXED) STRAIN: 13-19 (MIXED)

40.4 ±2.0 mg. N 141 ±11.6 mg. N 84. ±3.2 mg. N

402-403

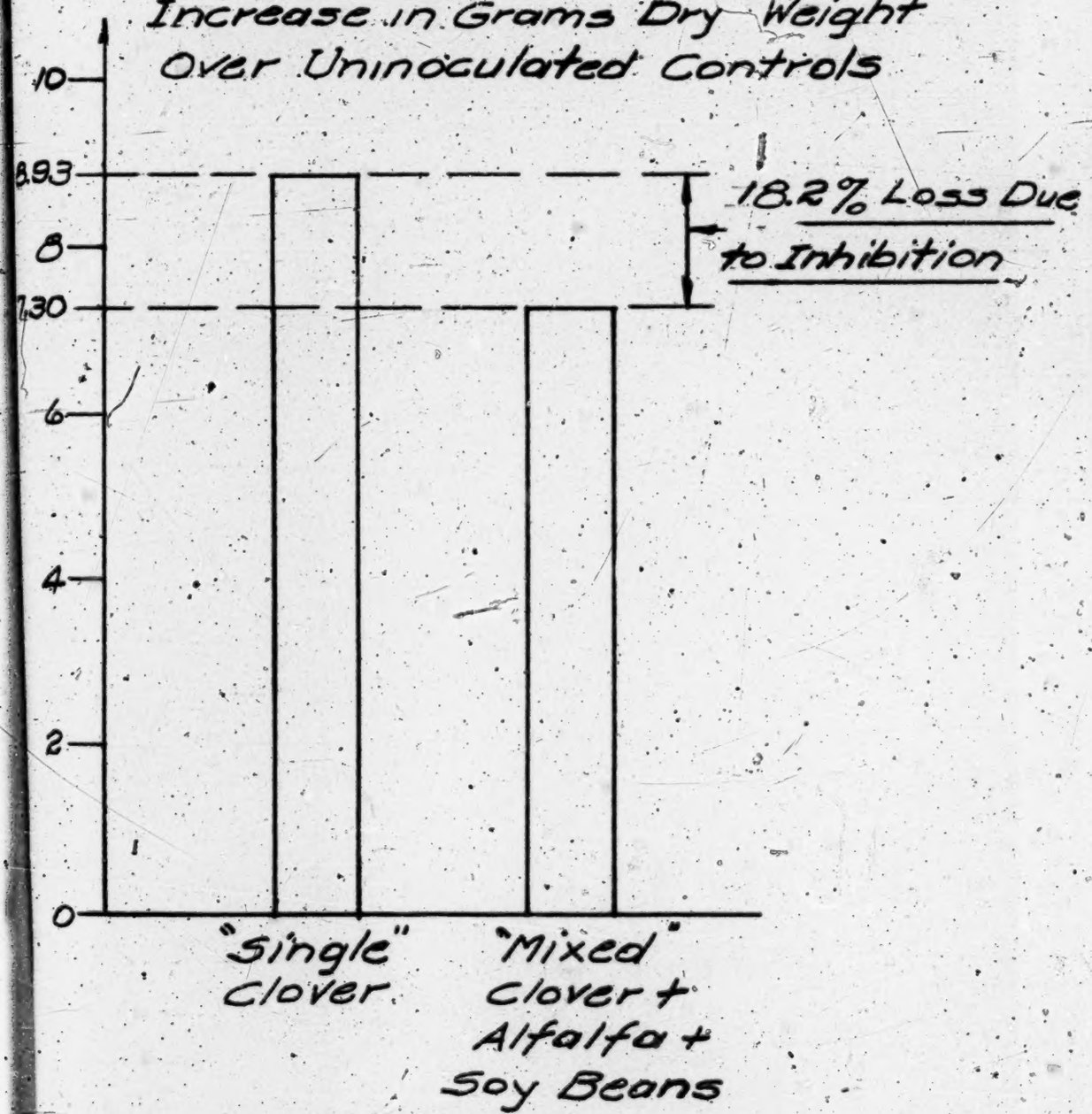
UNINOCULATED ± 8.0 mg. N

STRAIN: 95-96 (UNMIXED) 246 ± 12.0 mg. N

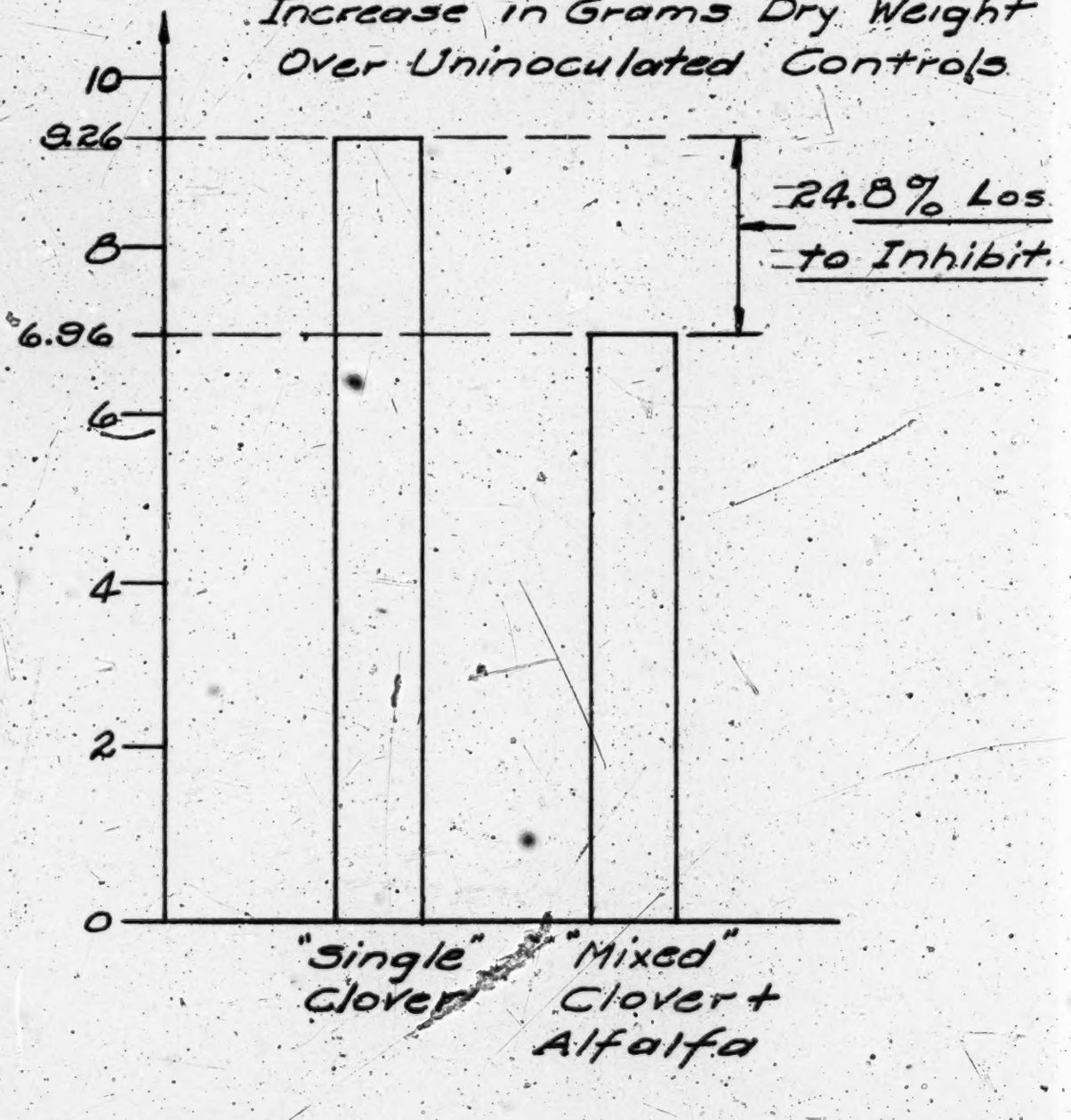
STRAIN: 95-96 (MIXED) 203 ± 11.4 mg. N

404-405

Reduction in Yield of Red Clover Due to Inhibition



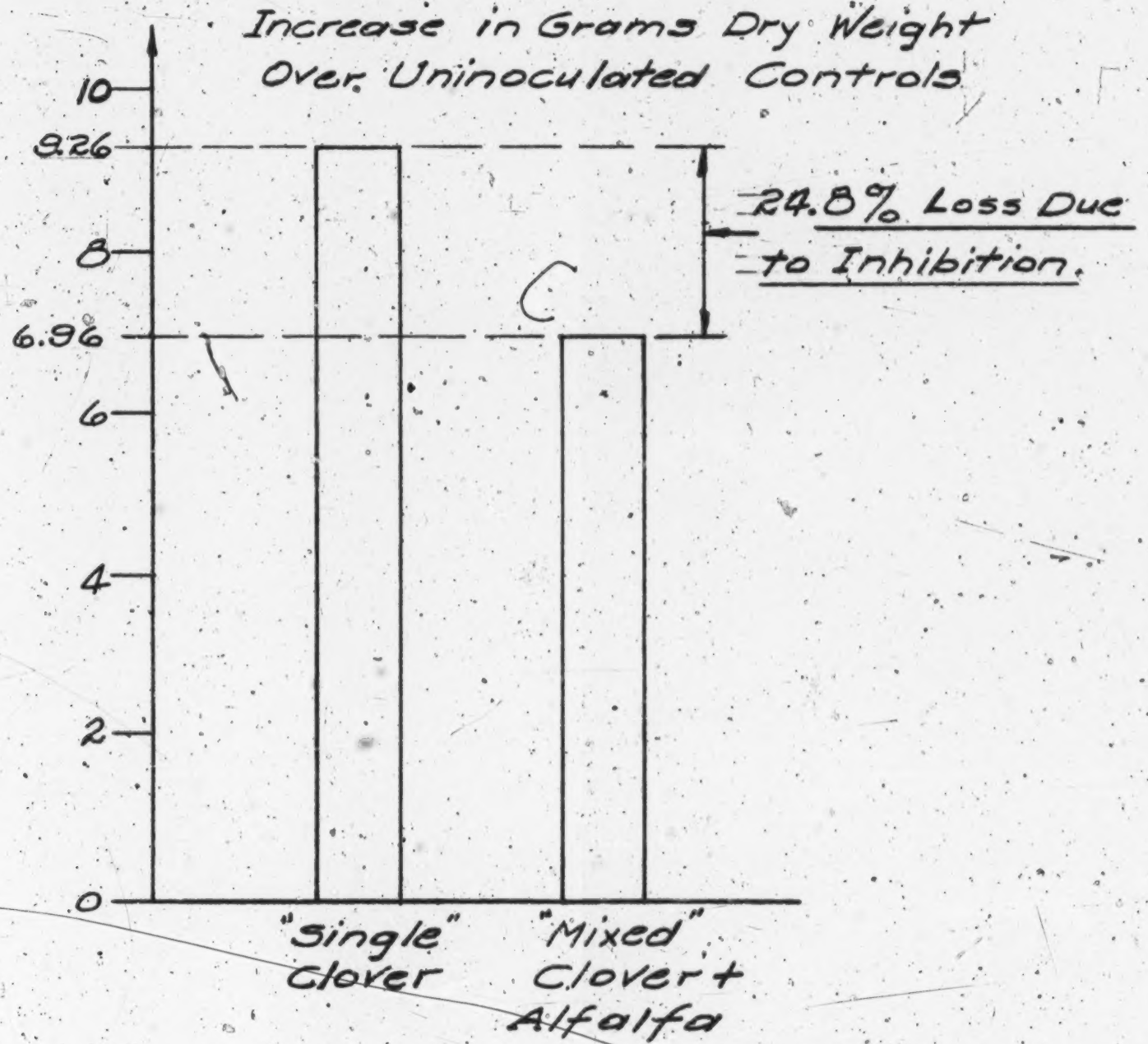
Actual Data from - V.S. Bond.



Actual Data from - Max. Kronberg

PLFS. EX. 16 IDEN.

Clover Due to Inhibition



Actual Data from—Max. Kronberger.

UNI CULTURE

KALO INOCULANT COMPANY

Quincy, Illinois

July 29, 1938

The Nitragin Co., Inc.,
Milwaukee, Wisconsin.

Atten: Mr. L. D. Matchette

Gentlemen:

I can well appreciate that the number of old Nitragin jobbers who have contracted for Uni-Culture, and its proven appeal to dealers, does concern you very greatly. I cannot, however, conceive of anyone sending out such misleading advertising as your bulletin of June 10th or certain letters you have written to jobbers.

You have made no test of Uni-Culture and have no evidence whatever that it is not in fact more effective than Nitragin. You have no knowledge as to how Uni-Culture is produced, but imagine an entirely different method by which you could produce a unit culture and falsely claim it to "be the equivalent of Uni-Culture". You even attempt to support your position with a quotation from a 1932 publication which was not based upon, and does not mention, a unit humus culture for field seed—and in spite of all this you still presume to venture an opinion as to the patent we expect both to secure and to sustain through the courts if necessary.

Under the circumstances we feel you will desire to immediately correct such misunderstandings as have been created by frankly admitting to the seed trade that your arguments have been based only upon the merest conjecture and not on knowledge of the facts.

We would like to hear from you in this connection and hope you will take steps to see that your own letters, the Company advertising, and the statements of the salesmen in the field comply with facts and information definitely in your hands, for we will hold you strictly accountable.

We are photostating this letter and will give it general circulation.

Very truly yours,

KALO INOCULANT COMPANY

MELusk/MA

Pub 9/17

President.

410-411

DIVISION OF BACTERIOLOGY

ROBERT S. BREED, Chief in Research
H. J. CONN, Chief in Research, Soil Bacteriology
G. J. HUCKER, Chief in Research
CARL S. PEDERSON, Chief in Research
M. W. YALE, Associate in Research
ALVIN W. HOFER, Associate in Research
J. R. SANBORN, Special Investigator
H. C. HAMILTON, Resident Doctor
MARY DARROW, Technician
WILLIAM C. HAYNES, Student Assistant
ROBERT F. BROOKS, Student Assistant
MARK FORD, Student Assistant

NEW YORK STATE
AGRICULTURAL EXPERIMENT STATION
GENEVA, N. Y.
P. J. PARROTT, Director

aly 29, 1938.

Mr. V. S. Bond
Kalo Inoculant Company
Quincy, Illinois.

Dear Mr. Bond:

In regard to the letter I sent you the other day there was one thing I omitted to mention. I noticed in a recent publication by Lochhead a statement to the effect that when bacteria of more than one cross inoculation group are placed in the same inoculant, one of the bacteria from these groups sometimes lose their efficiency.

Since this too is a point you will want to check over carefully, I think it wise to call your attention to it.

Yours very truly

Alvin W. Hofer.

A. W. Hofer.

PLFS. EX. 18 IDEN.

DIVISION OF BACTERIOLOGY

ROBERT S. BREED, Chief in Research
H. J. CONN, Chief in Research, Soil Bacteriology
I. J. HUCKER, Chief in Research
CARL S. PEDERSON, Chief in Research
E. W. YALE, Associate in Research
ALVIN W. HOFER, Associate in Research.
J. R. SANBORN, Special Investigator
H. C. HAMILTON, Resident Doctor
MARY DARROW, Technician
WILLIAM C. HAYNES, Student Assistant
ROBERT F. BROOKS, Student Assistant
MARK FORD, Student Assistant

NEW YORK STATE
AGRICULTURAL EXPERIMENT STATION
GENEVA, N. Y.
P. J. PARROTT, Director

July 19, 1938

Mr. B. S. Bond
Kalo Inoculant Company
Quincy, Illinois

Dear Mr. Bond:

Your letter of July 14th is at hand and I was very much interested to read your comments. In general, it seems to me that your comments in regard to my paper fit in very well with what I expressed there. As long as cultures contain 5,000,000 or more bacteria per pound of seed they are to inoculate, I feel confident that the number of organisms will be sufficient. Since the variation in numbers is so enormous, however, it seemed that for a manufacturer to be certain of having 5,000,000 legume bacteria per pound of seed in each of his containers, it would be necessary to try to maintain an average of at least ten times that number. While I have not studied variation in humus cultures to the same extent as in agar cultures, it is my opinion that the numbers of bacteria in humus cultures vary also.

There is one suggestion I should make in regard to your procedure and that is that if possible, you reduce the expiration date. The death of legume bacteria in humus is very rapid after the first two or three months and unless there is a definite need for a distant expiration date, it seems to me that it would be well to move that date forward so that the culture would be marked for good for only six months. Of course I realize that this may not be feasible in the case of Austrian peas and other such legumes. In the case of most cultures, however, the date could be much shorter than it is.

What you say in regard to your new culture combining clover, alfalfa, and soy beans in a single unit is very interesting to me. From the information you have given it seems that this type of culture may be practical. The only question I would have in regard to it would be that of expense. Since it will be necessary to put in an adequate number of each of these types of bacteria, the expense apparently would be much increased but perhaps the advantages of the culture would make up for that. What you state in regard to the advantages of washing agar cultures as a method of preparation of peat cultures has been observed in this laboratory. I think you are on the right track when you add a large number of nodule organisms and a small amount of nutrient material to the humus. I doubt whether there will be antagonism between the different types of legume organisms but you will need to be careful to add sufficient numbers of each type. There is a problem which sometimes occurs in such cultures, in my opinion, and that is that occasionally some of the strains lose their nodule forming ability. You should check on this point very carefully.

It will not be possible for me to be at the S.A. B. meeting this year although Dr. Conn is planning to attend. I do expect, however, to be at the Agronomy meeting in Washington. If you are present I should be very

PLFS. EX. 19 IDEN.

happy to see you and discuss these matters with you further. In fact, it might be worth while for some of us to plan to meet there early since the two days of the microbiological meetings are usually jammed full. It seems to me that you have a promising approach to a problem of legume inoculant manufacture and with the precautions you have already taken, it appears to be possible to make a more uniform type of culture to use. If there are any further developments, I should be very happy to keep in touch with them.

Yours very truly,

Alvin W. Hofer

Alvin W. Hofer

AWH:MC

PLFS. EX. 19 IDEN.

DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

DIVISION OF BACTERIOLOGY

PROGRESS REPORT OF THE DOMINION AGRICULTURAL BACTERIOLOGIST

A. G. LOCHHEAD, B.A., M.Sc., Ph.D.

FOR THE YEARS 1934, 1935, AND 1936

PLPS. EX. 20 IDEN.

Published by authority of the Hon. James G. Gardiner, Minister of Agriculture, Ottawa, 1938

To assist the Division of Animal Husbandry in the control of mastitis in the dairy herd, periodic examinations were made of all cows for infection by *Str. agalactiae*. According to the findings the animals were segregated into definitely infected, suspicious and non-infected groups, which permitted of better control in preventing the spread of the disease and in aiding its elimination.

SOIL MICROBIOLOGY

LEGUME CULTURE DISTRIBUTION

The distribution of cultures for the inoculation of legume seed to Canadian farmers was continued during the years 1934-36. The distribution of "nitro-cultures" was maintained for educational and experimental purposes, sufficient culture for the treatment of 60 pounds of legume seed being sent free to any farmer on the understanding that the user report the results.[1] The object was therefore (*a*) to encourage the more widespread practice of seed inoculation and (*b*) to accumulate the data on the practical results of seed treatment under field conditions. During the years under review the numbers of cultures distributed were 4,184, 5,407 and 5,867 respectively, making a total of 15,458 for the period. Of these, approximately 2,800 were sent to the Prairie Provinces in co-operation with the program of Government aid to farmers in drought areas.

RESULTS OF INOCULATION EXPERIMENTS CONDUCTED BY FARMERS

By means of reports returned by farmers receiving cultures for legume inoculation, the Division has been accumulating information over a period of 12 years on the practical benefits of seed treatment as judged by the farmers themselves, whose opinion will largely determine the value of any agricultural practice. A summary of reports received to the end of 1936 is presented in table 5, comprising data from 2,475 reports.

TABLE 5.—SUMMARY OF REPORTS OF LEGUME INOCULATION BY FARMERS

—	Alfalfa	Sweet clover	Red clover	Alsike clover	Peas	Vetches	Beans	Soy-beans	Lupines	Total
Total reports received	1,449	399	271	74	90	10	53	120	9	2,475
Benefit from inoculation	1,185	294	213	65	67	8	44	82	8	1,976
Percentage benefit	82·6	73·7	79·3	87·8	74·4	80·0	83·0	68·3	88·9	79·9
Legume grown for first time	1,183	311	179	40	53	6	37	108	8	1,886
Benefit from inoculation	1,007	234	107	36	36	5	26	78	7	1,534
Percentage benefit	85·1	75·2	82·3	90·0	67·9	83·3	70·3	72·6	83·8	80·6
Cases reporting no benefit	254	105	56	8	23	2	9	38	1	497
Treated and untreated crops grew well	137	36	20	2	9	2	3	21	-	230
"No catch" reported	38	17	13	1	3	-	3	1	-	76
Winter killed	3	4	1	-	-	-	-	-	-	8
Drought	26	34	12	3	6	-	1	1	-	73
Blown out	1	1	-	-	-	-	-	-	-	2
No reason given	49	23	10	3	6	-	2	15	1	109

From the table it is observed that the results are distinctly favourable to inoculation. There is reason to believe that not only in the case of alfalfa, but also for common clovers and other legumes, seed treatment may be a very useful practice. In approximately one-half of the cases where no benefit was noted, both treated and untreated crops grew well, indicating that the soil was already supplied with suitable bacteria rather than a failure of the culture. Although the percentage of favourable reports was slightly higher where legumes were grown for the first time, information from reports indicated that re-inoculation may be of value. Greenhouse tests, supplemented by field trials at Beaver-

[1] The general distribution was discontinued in 1937, satisfactory commercial cultures now being available.

lodge, have shown that different "strains" of legume bacteria may vary greatly in nitrogen-fixing capacity and so in their ability to aid a crop. The addition of a "good strain" of bacteria rather than the mere presence of nodule-forming bacteria in the soil is believed to be an important factor which explains the value of re-inoculation. (See figure 3.)

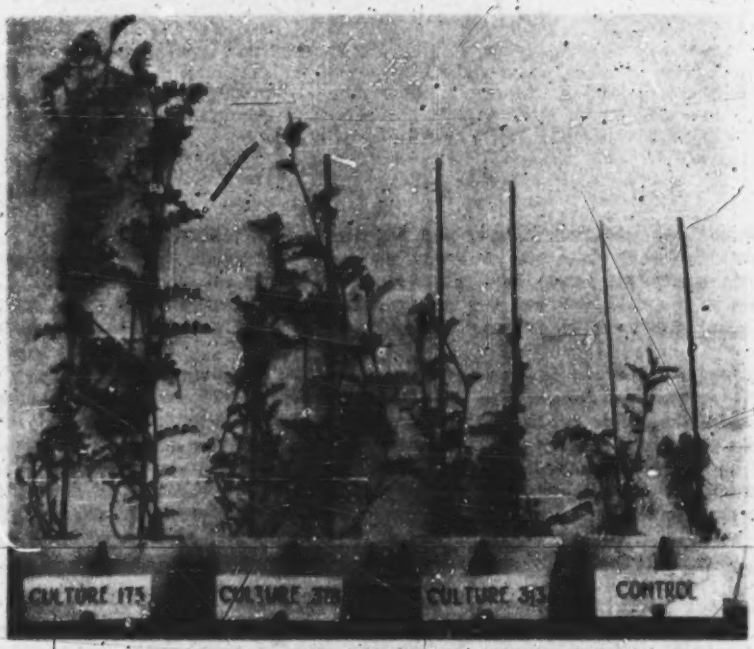


FIG. 3.—Variation in efficiency shown by different strains of nitrogen-fixing bacteria (*Rhizobium leguminosarum*) for vetch.

EXAMINATION OF MISCELLANEOUS INOCULANTS

During the three-year period a number of legume inoculants appearing on the market were examined. The tests undertaken consisted in estimating the number of organisms in the culture and in making greenhouse tests to note the ability of the culture to produce nodules on the appropriate legume plants when applied as directed. Seeds were sown in sterile sand to which was added plant food minus nitrogen with controls of uninoculated seed and of seed inoculated with a pure culture of *Rhizobium* corresponding to that of the inoculant.

Legume inoculants available to farmers in Canada are now believed to be generally reliable. Though various types are available, there is nothing to indicate that the dry method, in which the culture, in the form of a powder, is mixed dry with the seed, is to be preferred to the older method whereby the seed is moistened when the culture is applied. Moreover, inoculants containing bacteria for but one cross-inoculation group are believed better than those containing bacteria for two or more legume groups, since tests have shown that in mixed cultures one strain may become ineffective.

May 18, 1945

S A variation,

Dr. [redacted]
N. J. Agricultural Exp. Station
[redacted]
New Brunswick, N. J.

Dear Dr. Conn:

You may have heard of the lawsuit now pending between two inoculant companies, and which is scheduled to go to court in the near future. I am told that it will be necessary for me to testify, and since certain questions are involved that deal with problems with which you are familiar, I am wondering whether you would be willing to give me the benefit of your opinions.

Briefly, the question at issue revolves around certain statements in the patent. One is: "It has heretofore been considered impracticable to prepare a composite culture inoculant containing organisms which will cause nodulation on more than one of the cross-inoculation groups. This has not been done because it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented. For this reason, it has been considered desirable to use a culture containing a single species of organism rather than on containing a mixture."

Also, "As has been pointed out above, composite cultures for inoculating the seeds of leguminous plants have not generally come into use because of the inhibitory effect that certain strains of certain species of the Rhizobia have on each other."

A good deal of the case hinges around this question of inhibition of nitrogen fixation in one group by bacteria of a different group. Because of the importance of this point, I should appreciate knowing whether or not you believe that such an effect actually occurs.

The more answers there are to this letter, obviously, the better will be the measure of scientific opinion on the subject. Unless you object, it is my plan, if and when I am called, to include your answer with the evidence.

Assuring you of my great appreciation for any support you may give me in presenting this matter fairly, I am

Sincerely yours,

A. W. HOFER

AWH:B

From Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten (German Central Journal for Bacteriology, Parasitology, and Infectious Diseases), part II, vol XX, 1908, pp 61-71.

Reprinting prohibited.

Observations on the Action of Hiltner's Pure Cultures for Legumes.

(Report of Kaiser Wilhelm Institute for Agriculture, Bromberg, Germany).

By Prof. Dr. Gerlach and R. Vogel

With 3 figures

Part I

For the purpose of testing the action of Hiltner pure cultures on the development of serradella, lupines and soya beans, these plants were, in the spring of 1906, brought under cultivation in walled-in parcels with and without inoculation. The parcels were prepared in November 1905, that is, in such a way that the ground was first dug out at the places concerned to a depth of 1 meter. The ditches thus formed then received vertical brick walls of 1 meter height, after the removed soil was put back in at the same place from which it had been removed. There were thus obtained square parcels, open below, that is, in contact with the natural ground, of 1 sq. m. in area and 1 cu. m. in volume. The parcels line in the range of the drainage system of the experimental fields, by which system they were drained. The soil consists of humus sand resting on light-yellow sand. At a depth of about 2 meters there is encountered an impermeable clay layer. The soil contains:

0.092% of nitrogen
0.061% of phosphoric acid
0.025% of potassium
871 0.590% of total lime

Mechanical analysis showed:

gravel	0.4%
very coarse sand	1.6%
coarse sand	5.8%
medium-coarse sand	48.2%
fine sand	35.6%
erosive parts	8.4%
	100.0%

The earth which had been put back into the walled trenches remained lying during the winter of 1905-1906 in rough furrows. Whether legumes, particularly lupines and serradella had ever been cultivated in this ground, we do not know. In the previous 4-5 years, in any event, this was not the case, for the ground had lain fallow during this period, and carried an exceedingly luxuriant stand of weeds. The experimental arrangement can be seen from the following sketch:

1	2	3	4	5	11	12	13	14	15	21	22	23	24	25	uninoculated
6	7	8	9	10	16	17	18	19	20	26	27	28	29	30	inoculated
	serradella					yellow lupine					soya bean				

On April 4, 1906 each of the 30 parcels received a fertilization consisting of 12 grams of potassium in Kainit (equals 120 kg of potassium per hectare) and 10 grams of citric-acid solution in Thomas flour (equals 100 kg of phosphoric acid per hectare). Each of the parcels allocated for the cultivation of soya bean, 21-30, was also fertilized with 500 grams of lime carbonate (equals 5000 kg per hectare). On April 19th the serradella was sown in the parcels 1-10 and the lupine in the parcels 11-20. The soya bean was sown on May 3rd (1). The quantities of seed amounted to:

Serradella, 5 grams per parcel, scattered by hand, and raked in.

872 Lupine, 20 grams per parcel, divided into 4 rows each.

Soya bean, 20 grams per parcel, likewise divided into 4 rows each.

As can be seen from the sketch, the parcels 1-5, 11-15, and 21-25 received the uninoculated seeds and the parcels 6-10, 16-20 and 26-30 the corresponding uninocu-

lated seeds. Each of the inoculations occurred in such a way that the pure culture, together with the corresponding nutrient salts, were distributed in 1/4 liter of fresh milk, and the seeds were thoroughly wetted with the bacteria liquid thus obtained. To the serradella seed there was preliminarily added a small amount of earth from the corresponding parcels for the purpose of enabling a more uniform broadcasting. The sowing of these seeds occurred by broadcasting, while the lupine and soya beans were placed in rows, and, in the same way as the serradella seed, immediately covered with earth. The uninoculated seeds were, for the purpose of establishing the same conditions, wetted with an equal quantity of nutrient salts added with milk, and sown in the same way. The weather was very favorable in sowing the serradella and lupine, with an overcast sky. The next day it rained. When the soya beans were sown the sun was shining. Since the spring and summer of 1906 were dry, all of the parcels were sprinkled from time to time with tap water. The stand of the inoculated lupines was already better than that of the uninoculated by the beginning of June. They were colored a deep darkgreen, and were far developed. Plants of the inoculated parcels pulled out at random exhibited well developed nodules. On the uninoculated plants these were entirely absent. By June 10th there was present a pronounced difference in favor of the inoculated parcels, including the serradella. The inoculated plants had now acquired a darkgreen color, while the uninoculated serradella had a light-green appearance and
873 was retarded in growth. In the further course of vegetation the lupine was somewhat injured by larvae and the lupine fly. The number of sick plants was greater on the uninoculated than on the inoculated parcels. On June 14th each third plant of the uninoculated and inoculated parcel was pulled out by the roots. The former were entirely free of nodules, while the latter exhibited very well developed nodules, particularly on the top parts of the main roots. On June 25th the inoculated lupines exhibited a copious supply of buds, in which the yellow color of the flower could be seen. On the uninoculated plants there could not yet be observed the beginning of blooming. Toward the end of June there became very noticeable in all of the experi-

ments, among the uninoculated, weakly, pale-green plants, individual examples of dark-green, luxuriantly-developed plants, which exhibited a copious coverage of nodules. There must, therefore, either have been present in the soil of the experimental field active nodule bacteria, or there must have occurred, despite the greatest care, an infection of these parcels in the inoculation. On July 12th the lupines were harvested by cutting off the plants above the ground. They had already dropped most of their blossoms and acquired larger numbers of pods. The individual yields can be seen from the following table, from which there can be recognized considerable increases in yield due to the inoculation.

The tabulated values show that the yield of the uninoculated parcels was subject to greater variations than that of the inoculated parcels. In the former case there were present differences up to 1003 grams, but in the latter only up to 330 grams. Of both the inoculated and the uninoculated parcels we took 30 plants each for further study of the nodule conditions. The roots of all of the inoculated plants exhibited strongly developed nodules, nearly all of which were present at the top part of the main root. Of the 30 roots of the uninoculated

874

parcel No.		weight of the above-ground, green mass, grams	total yield, grams
11	uninoculated	2505.0	10,715.0
12		1500.9	
13		2110.0	
14		2500.0	
15		2100.0	
16	inoculated	3200.0	15,520.0
17		3070.0	
18		2900.0	
19		3120.0	
20		3230.0	

plants only three exhibited nodules. In 2 cases the nodules were present in the form of large spherical swellings on the bottom part of the main root, and in one case the main root was free of nodules while a number of nodules were present on a branch root. The remaining 27 roots of the uninoculated plants were entirely free of nodules. It is possible, and becomes very probable through the experiments described below,

that these nodules, occurring on the bottom part of the main root or on the branch roots, were caused by bacteria previously present in the soil. The nodules of the uninoculated plants of the parcels 11-14, which had been so outstanding through their luxuriant stand, were, conversely, as in the case of all of the inoculated plants, present on the top part of the main root. In this case, therefore, there must, as already mentioned, have occurred an infection through the inoculating bacteria. Surprising was the retarded root development of the inoculated plants.

On July 13th the 10 lupine parcels were, in observing the necessary precautions (using separate utensils for the inoculated and uninoculated parcels, etc.), scraped-flat, and, without reinoculation, again planted with lupine. Also this time there occurred clear differences in the development of the plants in favor of inoculation, which were clearly expressed in the harvest yields. Harvesting occurred on October 11th. The yields can be seen in the following tables:

875

parcel No.		weight of the above-ground, green mass, grams	total yield, grams
11		1029.0	
12		865.0	
13	uninoculated	918.0	4849.0
14		1001.0	
15		1036.0	
16		1645.0	
17		2028.0	
18	inoculated	1730.0	8364.0
19		1586.0	
20		1375.0	

There had thus been obtained in the form of green mass:

	uninoculated	inoculated
I. harvest	10,715.0 g	15,520.0 g
II. harvest	4,849.0	8,364.0
	15,564.0 g	23,884.0 g

The serradella of the 10 experimental parcels were harvested on August 8th, that is, again by cutting off the green mass above the ground. The harvest results were as follows:

parcel No.		weight of the above-ground, green mass, grams	total yield, grams
1		1612.0	
2		1586.0	
3	uninoculated	1681.0	8530.0
4		1931.0	
5		1720.0	
6		2179.0	
7		1795.0	
8	inoculated	1967.0	9985.0
9		1904.0	
10		2140.0	

This gives per parcel:

uninoculated	inoculated
1706.0 grams	1997.0 grams

of green mass.

All of the roots of the inoculated plants exhibited large masses of nodules, in many cases sitting together in the form of thick nests on the main root. With 876 the uninoculated plants, large numbers of nodules were present on about 50% of the roots, although these were mostly present on the branch roots.

With the soya beans the results of inoculation were apparently the least pronounced. They were ripe by September 15th, when they were harvested together with the roots. The yields can be seen from the following table:

parcel No.		weight, grams	total weight, grams
21		759.0	
22		777.0	
23	uninoculated	843.00	4259.0
24		970.0	
25		1010.0	
26		891.0	
27		1157.0	
28	inoculated	932.0	5676.0
29		1290.0	
30		1406.0	

Thus the yield per parcel was:

uninoculated	inoculated
871.0 grams	1135.2 grams

The roots of the uninoculated plants were entirely free of nodules. However, also in the inoculated par-

cels there were some plants whose roots had no nodules. The plants were kept for further drying in paper bags, after which the grain was removed from the stems. There were obtained:

from parcels 21-25 (uninoculated), 515 grams of grain, 1713 grams of straw

from parcels 26-30 (inoculated), 635 grams of grain, and 2031 grams of straw

In all cases, therefore, an increase yield was obtained through inoculation. All of the results are recapitulated in the following tables:

877 **Serradella**

(1) No.
(2) parcel No.
(3) treatment
(4) harvest per parcel
(5) nitrogen-content of green mass, percent
(6) harvested dry substance per parcel, grams
(7) harvested nitrogen per parcel, grams

1	2	3	4	5	6	7
1	1-5	uninoculated	1706.0	0.399	395.79	6.81
2	6-10	inoculated	1997.0	0.572	479.28	11.42

Yellow Lupine

(1) No.
(2) Parcel No.
(3) treatment
(4) harvest per parcel
  (a) 1st harvest
  (b) 2nd harvest
  (c) total.
(5) nitrogen-content of green mass, percent
  (a) 1st harvest
  (b) 2nd harvest
(6) harvested dry substance per parcel, grams
(7) harvested nitrogen per parcel, grams

1	2	3	4			5		6	7
			a	b	c	a	b		
3	11-15	uninoculated	2143.0	969.8	3112.8	0.267	0.353	427.28	9.15
4	16-20	inoculated	3104.0	1672.8	4776.8	0.436	0.448	656.34	21.03

878 **Soya Bean**
(1) No.
(2) parcel No.
(3) treatment
(4) harvest per parcel
(a) grain
(b) straw
(5) nitrogen-content, percent
(a) grain
(b) straw
(6) harvested dry substance per parcel, grams
(7) harvested nitrogen per parcel, grams

1	2	3	4		5		6	7
			a	b	a	b		
5	21-25	uninoculated	103.0	342.6	4.33	0.579	407.93	6.44
6	26-30	inoculated	127.0	406.2	4.40	0.580	481.52	7.94

At the same time inoculation gave the following increase in yield:

	dry substance, %	nitrogen, %
with lupine	53.6	129.9
with serradella	21.1	67.8
with soya bean	18.0	23.3

This was supposed to end the experiment, to be followed the next year with a watering experiment on lupine. The harvested parcels were dug around in the autumn, and were left lying over winter in the form of rough furrows. In the spring of 1907 we planted all of them with yellow lupine, all of which had been inoculated with Hiltner's pure culture. All of the parcels received on
879 March 21st a fertilization with potassium-phosphate. The sowing of the inoculated seed occurred on March 28th. During the growth of the lupine we now made the following interesting observations. As early as June 5th it was noticed that the lupine in parcels 1-10, which had carried serradella the previous year, exhibited a considerably stand than those in which there had previously grown lupine and soya bean. The plants were a deep dark-green and gave, as compared with the other lupines, the impression of plants which had been successfully inoculated. On June 18th there bloomed the lupines in the parcels 1-10 (previous crop, serradella); the stand was exceptionally thick, and the plants a deep dark-green. Of the considerably worse developed plants of the other parcels not one had yet bloomed. In the parcels 11-20 (previous crop, lupine), however, some of the plants had

begun to green and to develop vigorously. By far the worst was the stand in the parcels 21-30 (previous crop, soya bean).

On June 25th the lupines in all of the parcels were in full bloom, the best in the parcels 1-10 and the worst in the parcels 21-30. Measurements gave the following values:

average length of plants with roots

lupine from parcels 1-10 (previous crop, serradella), 55-60 cm

lupine from parcels 11-20 (previous crop, lupine), 40-45 cm

lupine from parcels 21-30 (previous crop, soya) 15-25 cm

On July 8th there were taken 12 plants each of the parcels of each of the groups for investigation. These weighed:

lupine from parcels 1-10 (previous crop, serradella), 705 grams

lupine from parcels 11-20 (previous crop, lupine), 265 grams

lupine from parcels 21-30 (previous crop, soya), 135 grams

The lupines following serradella were 65-75 cm long, and all were supplied with nodules, all of which were present on the top part of the main root, where they had brought about thick swellings. Only one of the 12 880 plants investigated also exhibited nodules on the branch roots, but also here on the top part. Of the lupines following lupines some exhibited nodules and some did not. The former possessed a length of about 58 cm and the latter one of 42 cm. Of the 12 plants, 7 had no nodules whatever. In the remaining 5, strongly-developed, thickly-projecting nodules were present, besides on the top part of the main root, also on the bottom part and on the branch roots. Nearly all of the lupines following soya seem to be light-green and sickly. Only a very few of the plants exhibited a better dark-green color. All 12 of the investigated plants were without nodules, and had an average length of 42 cm. In these plants the roots were longer and hence the above-ground plants shorter than the previous ones. One of the better-developed, dark-green plants exhibited a large nodule the size of a hazel

nut on the bottom part of the main root, as well as a few nodules on the branch roots.

On July 9th there were again taken 12 plants from each of the groups. The weights amounted to:

in group I, (previous crop, serradella), 675 grams
in group II (previous crop, lupine), 532 grams
in group III (previous crop, soya), 320 grams

The weights in groups II and III are comparatively high because there were purposely selected plants of a dark-green color and a good development, which were to serve for further study of the nodule conditions. This study gave the following picture. All of the roots of group I (see figure 1) exhibited the nodule joined in the form of bulbous swellings at the topmost part of the main root. The whole root system, as well as the plant, was very vigorously developed. The branch roots were without nodules in nearly every case.

Quite different in group II. Here infection had, obviously owing to less active bacteria, and also, as may be concluded from the later greening of the plants, set in 881 later. The whole root system here was more weakly developed. The nodules (see figure 2, No. 1, 2, 5, 6) were almost exclusively present on the branch roots. The nodules observed on the main root did not, in some of the cases (see No. 3, 4), sit on the topmost part, and did not, what we regard as particularly typical owing to its very constant repetition, form, like the very infective bacteria of group I, thick, bulbous, kidney-shaped swellings, but thickly-bulging balls. Such nodules present on the middle or bottom part of the main root would seem to be less active. This is confirmed by the picture presented by the roots of the plants of group III with their sparse supply of nodules. These lupines are the worst developed. As can be from No. 1 of figure 3, there is present on the middle part of the main root a spherically-bulging nodule which has been brought about by a virulent bacteria. Such nodules are also present on the branch roots (No. 2), but never on the top part of the main root. By far the majority of these plants of this group, however, fail to show any nodules on the roots (No. 3-6), as a result of which they present a very sickly appearance.

On July 11th there were again taken 12 plants of each of the groups, for the purpose of isolating the nodule bacteria. The weights amounted to:

Figure 1: serradella-lupine

Figure 2: lupine-lupine

Figure 3: Soya-lupine

12 plants of group I (previous crop, serradella), 638 grams
12 plants of group II (previous crop, lupine), 578 grams
12 plants of group III (previous crop, soya), 344 grams

882 On the plant roots the nodules are again distributed in the typical manner already described.

On July 12th the lupines were harvested. The plants were cut off right above the ground, so that the roots remained in the ground.

Group I (previous crop, serradella)

previous year

uninoculated		inoculated	
parcel 4, 3500 grams		parcel 9, 3435 grams	
parcel 5, 3950 grams		parcel 10, 3270 grams	
	7450 grams		6705 grams

7450 grams
6705 grams
2018 grams (harvested earlier)

16,173 grams equals 4043 grams per parcel

Group II (previous crop, lupine)

previous year

uninoculated		inoculated	
parcel 11, 2690 grams		parcel 16, 2850 grams	
parcel 12, 1334 grams		parcel 17, 2235 grams	
parcel 13, 842 grams		parcel 18, 1977 grams	
parcel 14, 1412 grams		parcel 19, 1922 grams	
parcel 15, 2032 grams		parcel 20, 2100 grams	
	8310 grams		11,084 grams

8,310 grams
11,084 grams
1,375 grams (harvested earlier)

20,769 grams equals 2077 grams per parcel

Group III (previous harvest, soya)

previous year	uninoculated		inoculated	
883	parcel 21,	632 grams	parcel 26,	683 grams
	parcel 22,	517 grams	parcel 27,	448 grams
	parcel 23,	815 grams	parcel 28,	725 grams
	parcel 24,	634 grams	parcel 29,	739 grams
	parcel 25,	595 grams	parcel 30,	602 grams
		3193 grams		3197 grams

3193 grams
3197 grams
799 grams (harvested earlier)

7189 grams equals 719 grams per parcel

Investigation of the harvested lupines gave:

lupine following	water	nitrogen
serradella	85.3%	0.450%
lupine	84.7%	0.449
soya	81.4%	0.275%

From this there is calculated:

	per parcel, grams.	
lupine following	dry substance	nitrogen
serradella	594.32	18.19
lupine	291.31	8.55
soya	133.73	1.96

The values bring out clearly the fact that the lupines following serradella have the highest yield of green mass, dry substance and nitrogen. There then follow those following lupine.

Still much lower is the harvest yield of the lupines following after the soya beans cultivated the previous year. This peculiar behavior of the lupines of this year's lupines becomes still more interesting through the circumstance that the seeds of all 30 the parcels were exactly the same kind, and had been inoculated with the same cultures, again furnished by Hiltner, which had had such a favorable effect on the development of the lupines the previous year. It would have been expected that the lupines
884 of this year in the lupine parcels of last year would give the highest yield, after which there would come the lupines following serradella. The inoculating bacteria in group II remained nearly inactive, as may be concluded from the large number of plants which remained without nodules. In group III they suffered a direct injury. In view of the perfectly uniform composition and

treatment of the soil of the 30 parcels it must, therefore, be assumed that the organism flora of the soil had been influenced through the legumes of the previous year in such a way that following serradella there predominated lupine bacteria acting very favorably on lupine, less favorably following lupine, and injuriously following soya. The development following serradella is excellent, no weakly-developed plants whatever being present. The bacteria present in the soil did not, therefore, harm the inoculating bacteria in any way, or else they are exceptionally active for lupine. Following lupine there did not occur the good action of the bacteria which was to be expected. This was even much less the case with group III. Here no inoculation effect occurred. The inoculation bacteria, supplied the previous spring, have been, under the unfavorable conditions prevailing following soya, either completely destroyed or rendered wholly inactive.

From a large number of typical nodules of the roots of groups I, II and III there have been obtained nodule bacteria in the pure culture. We shall undertake, in the spring, with the breeds obtained, inoculation experiments under the most various conditions.

In the isolation of the nodule bacteria from the root nodules of the various plants there was disclosed the peculiar and interesting phenomenon that the bacteria of the lupines grown following serradella, which had been regarded as particularly active, only grew retardedly and slowly in the artificial lupine nutrient soil (lupine agar according to Hiltner), while the bacteria of the crop rotations of lupine-lupine and soya-lupine grew luxuriantly right from the start. This behavior is wholly analogous to that of the pathogenic bacteria which usually thrive in artificial nutrient soil the better the more they have lost in virulence. It will attempt to favor the growth of the serradella-lupine bacteria through the addition of serradella root extract to the lupine nutrient soil.

885

We think that these experiments indicate that the bacteria of serradella and lupine are able to substitute each other, a fact which is in agreement with the opinion recently expressed by Hiltner concerning the homogeneity of nodule bacteria.

We shall endeavor to ascertain, through further experiments, the reason for the serious injury of the inoculating

bacteria for lupine grown after soya bean, as well as of the weak or low activity of these bacteria following lupine.

The above-mentioned watering experiments planned for 1907 have suffered a great deal through the peculiar behavior of this year's lupines. Nevertheless, the values found are so interesting that we give them below.

1907 was a very poor year in the province of Posen for watering experiments, since the precipitation during the summer was much higher than normal. There fell in the experimental fields in Bromberg:

	summer of 1907	normal precipitation (average of 1861-1895)
May	82.5 mm	45 mm
June	55.7 mm	62 mm
July	122.3 mm	62 mm
August	40.5 mm	55 mm
	201.0 mm	224.0 mm

Despite this, a small amount of watering even considerably increased the yield of lupine following serradella, while with the lupine following lupine and soya the watering had an injurious instead of a beneficial effect.

886		dry substance, grams	nitrogen, grams
Lupine following serradella			
	through natural precipitation	790.9	25.78
	ditto plus 150 mm of watering	1023.3	31.25
	ditto plus 300 mm of watering	1067.1	31.52
Lupine following lupine			
	through natural precipitation	273.1	8.01
	ditto plus 150 mm of watering	211.4	6.21
	ditto plus 300 mm of watering	255.4	7.48
Lupine following soya			
	through natural precipitation	143.2	2.10
	ditto plus 150 mm of watering	127.8	1.88
	ditto plus 300 mm of watering	111.4	1.64

The experiments show very clearly that the amount of water supplied to lupine—and the same thing is also true of the nutrient substances—cannot be properly and fully utilized unless the soil contains a sufficient amount of active nodule bacteria.

Footnote

(1) The soya beans used in the experiments, as well as all of the inoculating cultures, were made available to us through the friendly cooperation of Dr. Hiltner, State Councilor, Munich.

(Translated by Carl Demrick)

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		—GARDEN SIZE— FOR PEAS, BEANS, SWEET PEAS AND LIMA BEANS. For 10 lbs. Seeds (3) 50c.
ALL VETCHES, CANADA FIELD PEAS, BROAD BEANS, SWEET PEAS, PERENNIAL PEAS, GARDEN PEAS	3	EACH CULTURE HAS BEEN SCIENTIFICALLY SELECTED FOR THE PARTICULAR GROUP OF SEEDS FOR WHICH INTENDED.
GARDEN PEAS, GARDEN BEANS, SWEET PEAS, ANY VARIETY	5	
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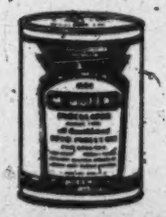

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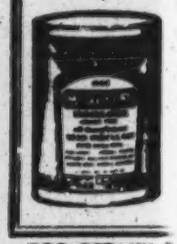

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PACKET—Inoculates up to 4 lbs. of Seed - - - 10c

INOCULATE WITH McQUEENS

FOR RETAIL CIRCULARS **"R"** CATALOGS & NEWSPAPERS

McQUEENS
THE GUARANTEED
INOCULATOR
CONTAINING MANY BILLIONS
Efficient Nitrogen-Fixing Bacteria
To Increase Crop Yields and Build Up Soil Fertility

Small Seeds ALFALFA and all CLOVERS	Large Seeds SOY BEANS COW PEAS LESPEDEZA	RETAIL PRICES
½ lbs.	1 lbs.	$ .30
1 lbs.	2 lbs.	.50
2½ lbs.	5 lbs.	1.00
	10 lbs.	1.85
	20 lbs.	2.50

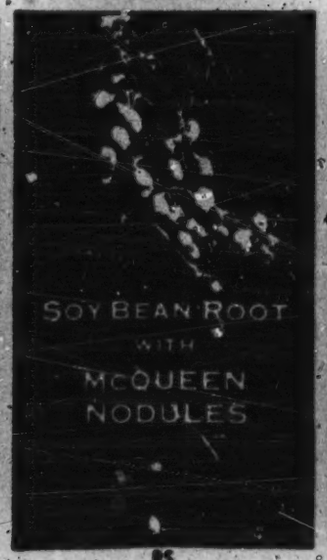
Garden Group: For Peas, Beans, Sweet Peas, Lima Beans
MARKET Size - - - for ½ lbs. of Seed - - - 25c
PACKET—Inoculates up to 4 lbs. of Seed - - - 10c

ALWAYS ORDER BY NAME OF SEED

INOCULATE WITH McQUEENS

FOR RETAIL CIRCULARS **"T"** CATALOGS & NEWSPAPERS

RA



RS

RV

Liberal use of these electros will stimulate sales of McQUEEN'S

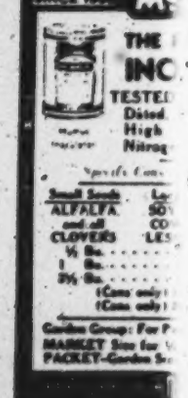
McQUEENS
THE FAST-SELLING
INOCULATOR
TESTED AND APPROVED
Dated, Protected Package, High Count, Efficient Nitrogen-Fixing Bacteria.

Small Seeds ALFALFA and all CLOVERS	Large Seeds SOY BEANS COW PEAS LESPEDEZA	WHOLESALE PRICES	RETAIL
½ lbs.	1 lbs.	$ .25	$ .30
1 lbs.	2 lbs.	.30	.50
2½ lbs.	5 lbs.	.60	1.00
	10 lbs.	1.00	1.85
	20 lbs.	1.70	2.50

Garden Group: For Peas, Beans, Sweet Peas, Lima Beans
MARKET Size for ½ lbs. per doz. $2.00 each 25c
PACKET—Garden Size per doz. .20 each 10c

ALWAYS ORDER BY NAME OF SEED

FOR WHOLESALE **"X"** PRICE LISTS & CATALOGS



FOR WHOLESALE

DISCARD ALL ELECTROS WITH OLD PRICES — USE THE HANDY ORDER

UEEN'S INOCULANTS

GUARANTEED
McQUEENS
HUMUS INOCULATOR

No. 3

INOCULATE ALL LEGUME SEED WITH

No. 23

INOCULATE THIS SEED WITH

No. 24

FOR PEAS, BEANS, SWEET PEAS WE RECOMMEND

No. 25

ARDEN SIZE
et Inoculator
es up to 4 lbs. of Seed

Only 10c

Insures Bigger and Better Quality Peas Beans, Lima Beans. Sweet Peas, Lupines

IL "P" CATALOGS & NEWSPAPERS
RS

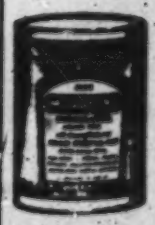
UEENS
AST-SELLING
LTURE
AND APPROVED
ber Color Bottle,
Guaranteed, High
ficient Strains of
-Fixing Bacteria

S WHOLESALE
A PRICES RETAIL
..... $ .10
..... .20
..... .30

Y NAME OF SEED

PRICE LISTS & CATALOGS

MARKET SIZE INOCULATOR



For 15 Lbs. of SEED - **25c**

Insures High Yields and Best Quality.

Billions of Bacteria For Inoculating Garden Peas & Beans Sweet Peas, Lupines and Lima Beans.

FOR RETAIL CIRCULARS "M" CATALOGS & NEWSPAPERS

UEENS
FAST-SELLING
CULATOR
AND APPROVED
Protected Package,
Count, Efficient
n - Fixing Bacteria.

S WHOLESALE
A PRICES RETAIL
..... $ .10
..... .20
..... .30
..... .40
..... 1.60
..... 1.70

Sweet Peas, Lima Beans
per doz. $2.40 each 25c
per doz. .50 each 10c

Y NAME OF SEED

PRICE LISTS & CATALOGS

McQUEENS

THE FAST-SELLING
INOCULANTS
TESTED AND APPROVED
Dated, Protected Package, High Count, Efficient Nitrogen - Fixing Bacteria.

Specify Cans or Bottles and Name of Seed

Small Seeds ALFALFA and all CLOVERS	Large Seeds SOY BEANS COW PEAS LESPEDEZA	WHOLESALE PRICES	RETAIL
½ Bu.	1 Bu.	$ .10	$ .20
1 Bu.	2 Bu.	.20	.30
2½ Bu.	5 Bu.	.40	1.60
	(Cans only) 10 Bu.	1.60	1.70
	(Cans only) 20 Bu.	1.70	1.80

Garden Group: For Peas, Beans, Sweet Peas, Lima Beans
MARKET Size for ½ Bu. per doz. $2.40 each 25c
PACKET—Garden Size per doz. .50 each 10c

FOR WHOLESALE "W" PRICE LISTS & CATALOGS

NDY ORDER CARD

Defendant's Exhibit 5.

893 EFFICIENCY OF CLOVER BACTERIA AS AFFECTED BY ALFALFA BACTERIA.

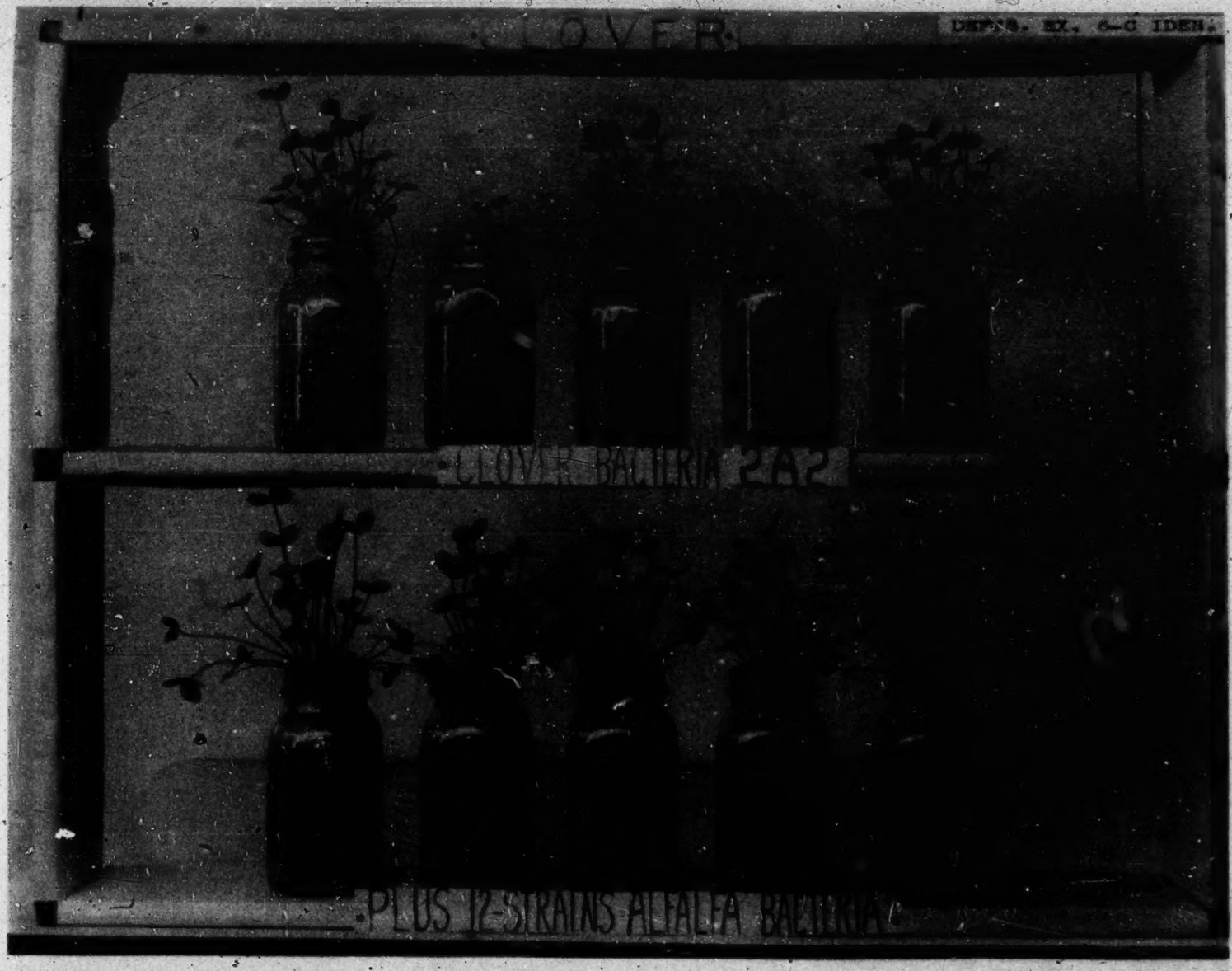
October 27, 1944

Strain	Weight Per Jar	Effect of Alfalfa	Nitrogen	Effect of Alfalfa
201	556 mgm.		21.8 mgm.	
201 Alfalfa	506	— 50	19.8	— 2.0
202	760		32.2	
202 Alfalfa	740	— 20	31.4	— 0.8
2A1	566		24.6	
2A1 Alfalfa	752	+186*	31.4	+ 6.8
2A2	334		14.6	
2A2 Alfalfa	728	+394*	32.0	+17.4*
2A3	650		27.8	
2A3 Alfalfa	[illegible]	— 90	22.6	— 5.2
2A4	292		13.2	
2A4 Alfalfa	654	+362*	28.8	+15.6*
2A5	280		11.2	
2A5 Alfalfa	652	+372*	27.2	+16.0*
2A6	316		13.6	
2A6 Alfalfa	710	+394*	29.6	+16.0*
2B1	520		22.2	
2B1 Alfalfa	788	+268	33.4	+ 9.2
2B2	538		21.8	
2B2 Alfalfa	694	+156	29.2	+ 7.4
2B3	620		25.6	
2B3 Alfalfa	752	+132	32.0	+ 6.4
2B4	316		13.4	
2B4 Alfalfa	722	+406*	30.0	+16.6*
All Clovers Mixed	364		15.8	
Clovers & Alfalfa	1020	+656*	41.8	+26.0*
AVERAGES				
Clovers alone	479		20.2	
Clovers & Alfalfa	688	+209	28.1	+ 7.9

* Difference statistically significant.

DEPTS. EX. 6-A IDEN.
BACTERIA 202
PLUS 12-STRAINS ALFALFA BACTERIA
447-448

DEFTS. EX. 6-B IDEN.
OVER.
PLUS 12 STRAINS ALFALFA BACTERIA.
449-450


CLOVER
DEFNS. EX. 6-C IDEN.
CLOVER BALTIKA 2 A2
PLUS 12 STRAINS ALFALFA BALTIKA C

451-452

CLOVER
DEFTS. EX. 6-D IDEN.
CLOVER BACTERIA 2A3
PLUS 12 STRAINS ALFALFA BACTERIA
453-454

OVER
DEPTS. EX. 6-E IDEN.
CLOVER BACTERIA 2A4
PLUS 12-STRAINS ALFALFA BACTERIA

455-456

CLOVER
DEPTS. EX. 6-F IDEN.
CLOVER BACTERIA 2A5
PLUS 12-STRAINS ALFALFA BACTERIA

457-458

459-460

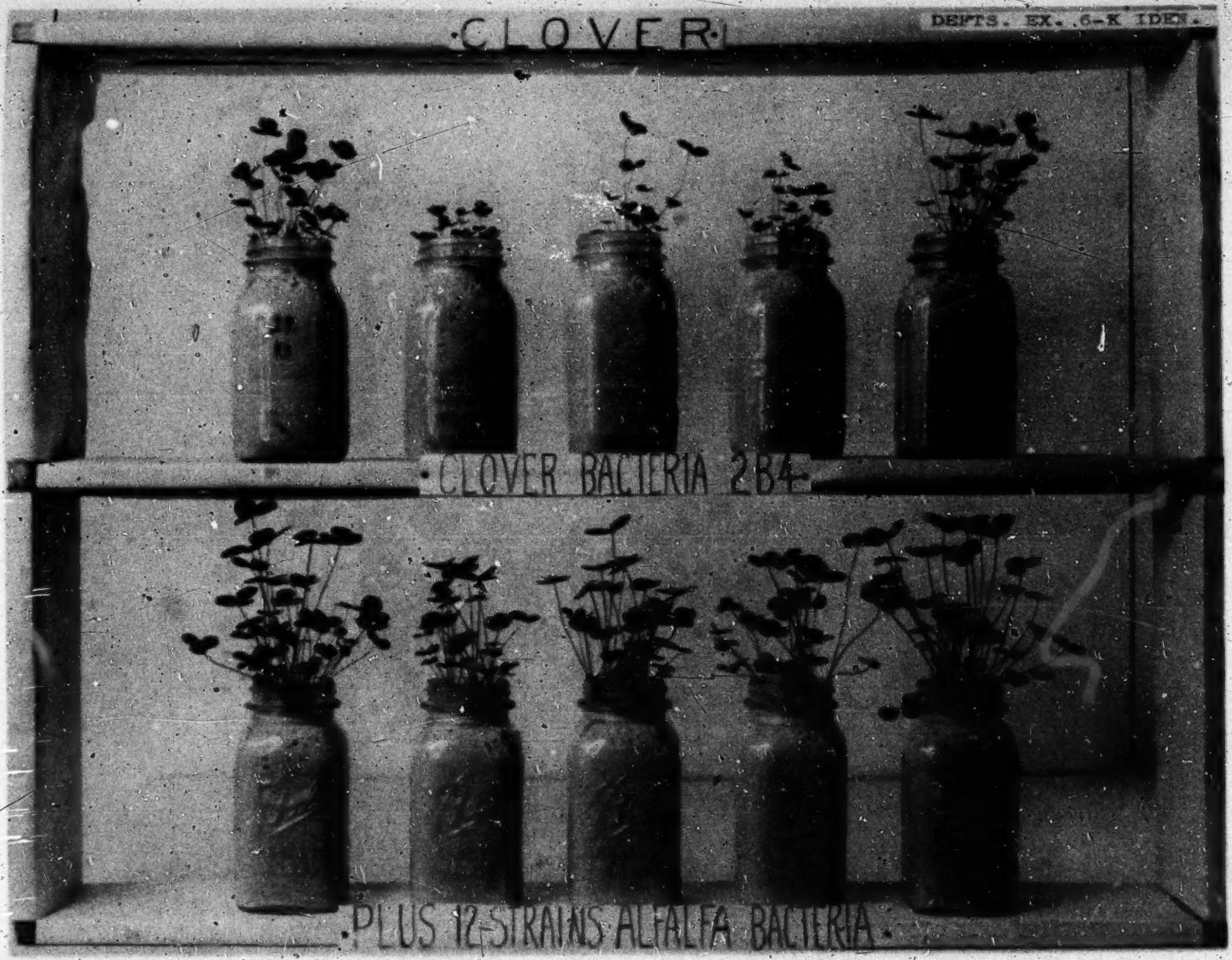
461-462

DEPTD, EX. 6-I IDEN.

463-464

OVER
DEPTS. EX. 64J IDEN.
CLOVER BACTERIA 2B3
PLUS 12-STRAINS ALFALFA BACTERIA

465-466


CLOVER
DEPTS. EX. 6-K IDEN.
CLOVER BACTERIA 2B4
PLUS 12 STRAINS ALFALFA BACTERIA

467-468

CLOVER
DEPTS. EX. 6-L IDEN.
12 STRAINS CLOVER BACTERIA
PLUS 12 STRAINS ALFALFA BACTERIA
469-470

906 DEFENDANT'S EXHIBIT 7.

The Effect of Alfalfa Nodule Bacteria (Rh. meliloti) on the Activity of Clover Nodule Bacteria (Rh. trifolii).

I. H. Curie

The result of these tests demonstrate to a scientist that there is no antagonism or inhibitive effect growing out of a combination of different groups of Rhizobium bacteria.

On January 27, 1944, a carefully controlled series of greenhouse tests was set up to check this theory of inhibition between the bacteria of the alfalfa and clover groups.

The tests were made by planting red clover seeds in quart Mason jars containing sterile quartz sand supplemented with all essential mineral nutrients except nitrogen and were inoculated as indicated below. Each group or series of seeds was planted in a series of six jars. Six plants were allowed to grow in each jar. Sterile distilled water was added as necessary.

1. One jar of each series was uninoculated.
2. Twelve series of jars were set up and each series inoculated with one strain of clover nodule bacteria in single culture unmixed with bacteria of other species.
3. Twelve series of jars were set up and each series inoculated with one strain of clover nodule bacteria mixed with a suspension of alfalfa nodule bacteria containing the same strains as used in the preparation of Legume-Aid.

The plants were allowed to grow in the greenhouse under identical conditions for a period of two months. At the end of this period the plants in the uninoculated jars were dead or dying and so small that no top growth could be harvested. The plants in the inoculated jars were cut at the surface of the sand, dried to constant weight in the oven and the weight for each jar recorded. The results are summarized below:

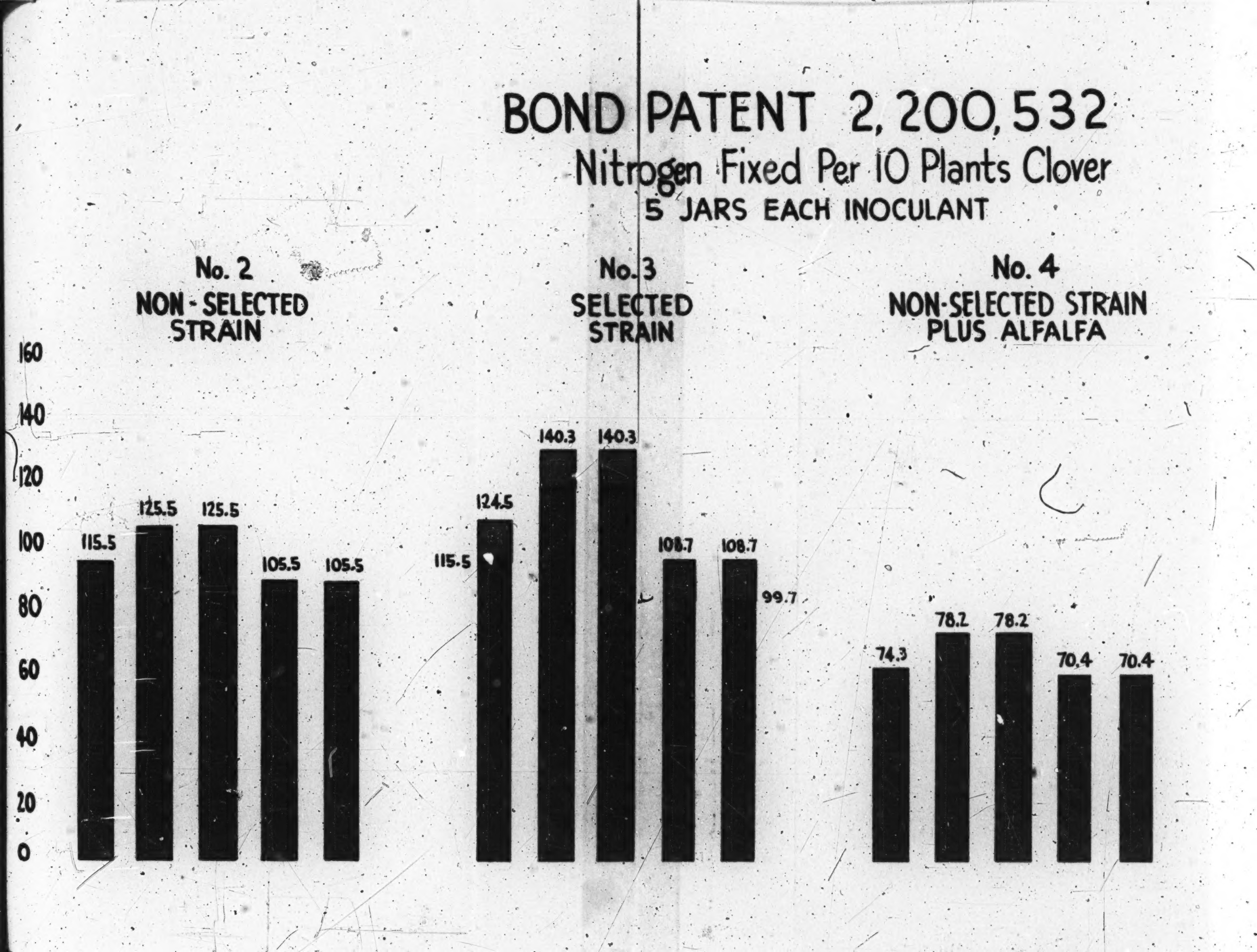
Clover Strain Number	Isolated (Year)	Plant Weight Per Jar	Effect of Alfalfa
201 Clover alone	1922	242 mg.	+158 mg. *
201 plus Alfalfa		420	
202 Clover alone	1935	1226	—116 *
202 plus Alfalfa		1110	
2A1 Clover alone	1932	922	+ 98
2A1 plus Alfalfa		1020	
2A2 Clover alone	1932	1198	+ 82 *
2A2 plus Alfalfa		1280	
2A3 Clover alone	1921	1212	— 62
2A3 plus Alfalfa		1150	
2A4 Clover alone	1941	1162	+152 *
2A4 plus Alfalfa		1314	
2A5 Clover alone	1941	1248	+ 98
2A5 plus Alfalfa		1346	
2A6 Clover alone	1941	1120	+ 20
2A6 plus Alfalfa		1140	
907 2B1 Clover alone	1920	1172	— 20
2B1 plus Alfalfa		1152	
2B2 Clover alone	1926	1146	— 20
2B2 plus Alfalfa		1126	
2B3 Clover alone	1938	1088	+ 62 *
2B3 plus Alfalfa		1150	
2B4 Clover alone	1938	780	— 8
2B4 plus Alfalfa		772	
AVERAGES			
Clover alone		1043	+ 39
plus Alfalfa		1082	

* Difference statistically significant.

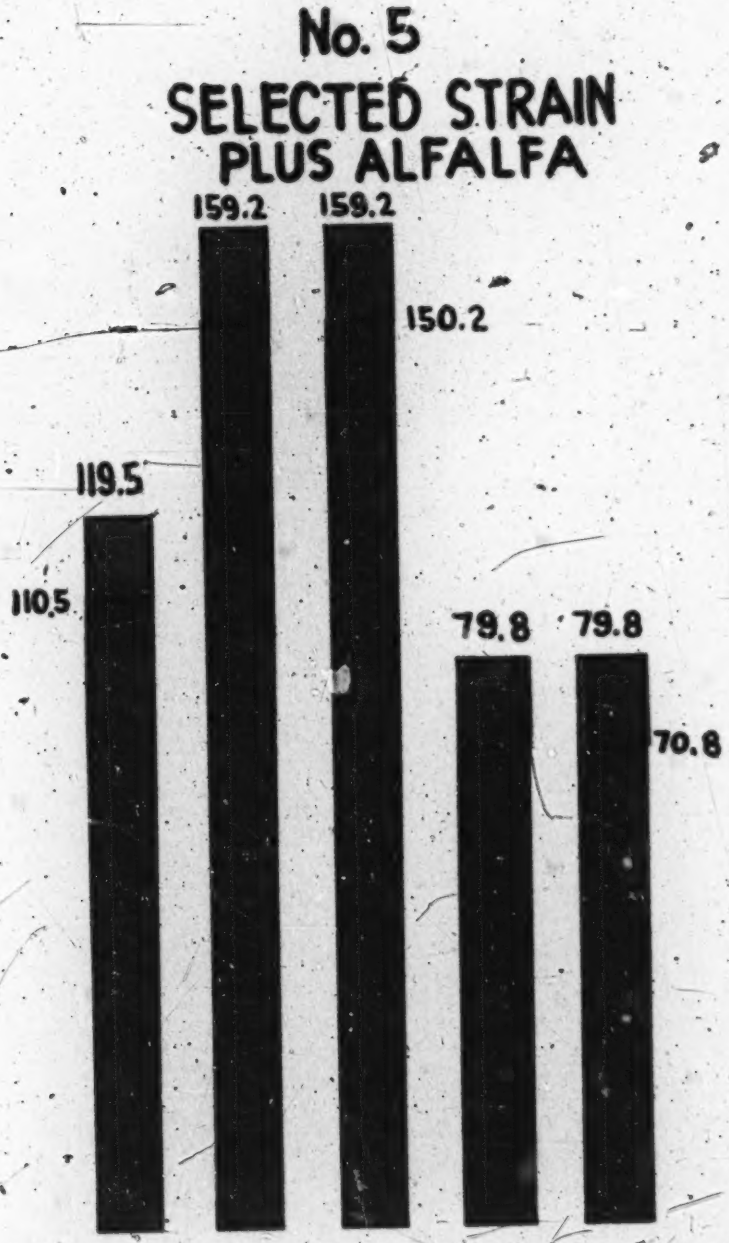
BOND PATENT 2,200,532

Nitrogen Fixed Per 10 Plants Clover

5 JARS EACH INOCULANT



DEFTS. EX. 8 IDEN.



909 DEFENDANT'S EXHIBIT 9.

June 30
1941

Dr. H. W. Bachelor
Ohio Agri. Expt. Station
Wooster, Ohio
Dear Dr. Bachelor:

Enclosed you will find the announcement of our Combination Culture for alfalfa and clover.

This past season we produced a quantity of this mixed culture under regular production methods, not laboratory experimental methods. This goods was date coded and sent into one section of the country in place of our regular Alfalfa and Clover. Six samples were picked up and tested by the state laboratory and all were found satisfactory. We are not using "alpha strains."

I believe Mr. Bond has written you that he has resigned from our organization and gone back to Kalo Inoculants. We were amazed, but I am sure we will be able to find a satisfactory man in the near future.

With best regards, I am,

Yours very truly,

I. H. Curie

IHC:HE

ELECTROS FOR YOUR CATALOG

If you do not want to use the full page space or the half page space, you can use smaller space and some of the electros listed below. **US TO GET UP THE COPY FOR YOU**, telling us just what size space you have. We will do this promptly without charge.

Cut No. 1

Cut No. 24

Cut No. 30

Cut No. 29

Cut No. 10

Cut No. 7

Cut No. 31

Cut No. 11

Cut No. 14

Cut No. 42

Cut No. 13

Cut No. 12

Cut No. 07

Cut No. 06

476-477

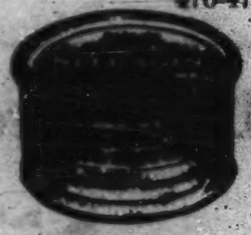
Awarded Gold Medal World's Fair
St. Louis, 1904—10 Years Ago

The Improved Soil Inoculator, Nobbe-Hiltner Process

NITRAGIN

Restores and Maintains Soil Fertility

THE ORIGINAL SOIL INOCULATOR



Sold in the Greatest Problem
An Exclusive Feature

NITRAGIN FACTS

THAT BEAR GREAT WEIGHT

1. IT is the first of its kind, the original pure culture legume inoculator; to which facts scientific text books and trademark records bear indisputable evidence. (Consult any Library.)

2. IT was invented by Nobbe & Hiltner, world famous soil experts, who discovered the science of legume inoculation with nitrogen fixing bacteria in 1896—TWENTY-SEVEN YEARS AGO.

3. IT was registered in the United States with trademarks "NITRAGIN" December 6th, 1898—TWENTY-FIVE YEARS AGO.

4. It was awarded a Gold Medal at the St. Louis World's Fair 1904—NINETEEN YEARS AGO.

5. IT has stood up under every test for TWENTY-SIX YEARS.

6. IT has been marketed in practically every agricultural country on earth for more than TWENTY YEARS.

7. IT has thrived and grown stronger in popular opinion year after year, in spite of hardships, prejudices and the rigid tests to which every great invention is more or less subjected.

8. IT is one of the most universally and highly endorsed products on the world's markets. IT HAS MANY IMITATORS.

9. IT is endorsed by Farmers, Experimental Stations, Agricultural Colleges, Agricultural Journals, Text Books, Soil Experts, Scientists and Educators the world over.

To see that your high grade seed is successfully inoculated means more than just a side-line profit. It means MORE SEED SALES, MORE SEED PROFITS, AND MORE SATISFIED CUSTOMERS.

CATALOGUE NITRAGIN

SOLD ON BUSHEL BASIS—NOT ACRE SIZES

Prominent Seed Houses heartily endorse this plan of selling NITRAGIN on the bushel basis instead of in acre sizes. This plan is practical. We predict all cultures for soil inoculation will soon be sold on the bushel basis.

A Great Price Reduction

Instead of the farmer paying one dollar per acre or more, he will only pay one dollar per bushel of seed inoculated. This cuts the price to the farmer to as low as 20c per acre, depending on the amount of seed he sows per acre.

A Double Profit to Dealers

As you will see by looking at the dealers prices on the inside page, your profits from the sale of NITRAGIN are BIG. We are told by our seed house customers that their profit on seed is also increased—because NITRAGIN used with their legume seed ASSURES A BETTER CROP.

LET NITRAGIN be a feature this year—it's too big for a side line

Def. [redacted] EX. 10 IDEN.

(FOR FULL PAGE) No. 60

Larger Crops in Field and Garden

If you use

The Improved Soil Inoculator, Nitro-Culture Process

NITRAGIN

Restores and Maintains Soil Fertility

Registered in the United States Dec. 6th, 1898.
25 YEARS AGO.

Awarded Gold Medal
World's Fair - St. Louis
1904.
19 YEARS AGO.

Alfalfa, clovers, soybeans, vetches, peas, beans, cowpeas, peanuts and other legumes should always be inoculated with Nitragin. The lack of necessary bacteria in the soil is often the cause of a poor legume crop—a weak start—or a total failure.

The modern farmer says: "I inoculate with Nitragin because I want a better "catch." I want plenty of those little nodules or germ lumps on every root. Nitragin nodules are plant food (nitrogen from the air) They mean well fed legume plants; big crop; less winter killing; better soil."

A Great Price Reduction

NITRAGIN Costs Less

NITRAGIN now comes in bushel sizes instead of acre sizes. This means that it costs you less per acre than inferior imitations. If you sow 12 pounds of seed to the acre it will only cost you 20 cents for your Nitragin. It means that

Your Dollar Goes Further With NITRAGIN

Nitragin is an old, reliable inoculator. At the low price of 20 to 33 cents per acre you cannot afford to sow legumes without it. Nitragin is put up in the modern ventilated package; in a rich, soil-like packing medium. The contents are always fresh, living bacteria to feed your plants. Easy to use.

EVERY GARDEN NEEDS NITRAGIN

New Garden Culture For Peas and Beans
See Below

PRICES

½ Bushel size.....40c Postage.....4c
¼ Bushel size.....60c Postage.....5c
1 Bushel size.....$1.00 Postage.....7c
5 Bushel size.....$4.75 Postage.....15c
Garden (peas, beans, sweet peas - three in one package).....20c Postage.....2c

STATE WHAT CROP YOU WANT THE NITRAGIN FOR

Your Best Paying

Will be one with—The Improved Soil Inoculator, Nitro-Culture Process NITRAGIN Restores and Maintains Soil Fertility —With

Use Your Catalog for NITRAGIN

You give counter and catalog space for selling seed. For your c
should **use catalog space for NITRAGIN.**

(FOR HALF PAGE) (No. 61)

IMPORTANT

NITRAGIN COSTS YOUR FARMER LESS per acre—make this your big point when pushing Nitragin sales. Your profit per can is as big as ever. This is because we are now selling Nitragin on a bushel basis instead of the acre size.

Neatly designed carton containing 12 Garden Size for counter display.
A neat cut for Garden Catalogues.

LARGER CROPS in FIELD a

If you use

Registered in the United States Dec. 6th, 1898.
25 YEARS AGO.

NITRAGIN Restores and Maintains Soil Fertility

Alfalfa, clovers, soybeans, vetches, peas, beans, cowpeas, peanuts and other le... Nitragin. The lack of necessary bacteria in the soil is often the cause of a po... failure.

A Great Price Red

NITRAGIN Costs Less

Nitragin now comes in bushel sizes instead ... bushel size per acre than inferior imitations. If ... 12 pounds of seed to the acre it will only cost you 20 cents for your Nitragin. It ...

Your Dollar Goes Furthe

Nitragin is an old, reliable inoculator. At ... price of 20 to 33 cents per acre you cannot afford to sow legumes without it. Ni... put up in the modern ventilated package; in a rich, soil-like packing medium. ... contents are always fresh, living bacteria to feed your plants. Easy to use.

EVERY GARDEN NE

New Garden Culture for ... See Below

PRICES

½ Bushel size.....40c P...
¼ Bushel size.....60c P...
1 Bushel size.....$1.00 P...
5 Bushel size.....$4.75 P...
Garden (peas, beans, sweet peas - three in one package).....20c P...

STATE WHAT CROP YOU WANT THE NITRAGIN F...

OUR 1923 PRICES

Small ... are sent direct to wholesale and catalogue seed houses, or direct from our laboratory to the customers of ... seed houses. Prices are:

			Wholesale	Retail	Consumer	
½ Bu.	Inoculates	12 lb of seed	$ .20	$ .30	$ .40	F. O. B. Milwaukee
¼ "	"	30 " "	.30	.45	.60	
1 "	"	60 " "	.50	.70	1.00	
5 "	"	5 Bu. "	3.25	3.75	4.75	

QUANTITY PRICES—NON-RETURNABLE

10 Tins — based on BUSHEL size — Discount 10 } F. O. B.
100 " " " " " 15 } Milwaukee
250 " " " " " 20 }

You can order all one kind or assorted

EXPLANATION:
4—¼ Bu. are equivalent to ONE bushel
2—½ " " " " "
1—5 Bu is equivalent to FIVE bushels

GARDEN SIZE

For Peas, Sweet Peas and Beans (3 in one). Sent in neatly assorted cartons for Counter display. 1 dozen in each carton.

	Wholesale	Retail	Consumer	
Each Lone	$ .15—1 to each	$ .25—1 to each	20c Ea.	F. O. B. Milwaukee
12 Cartons	1.65—12 to each	2.50—12 to each	$2.00 Ea.	
Total	19.80—12 to each	27.50—12 to each	24c Ea.	

The NITRAGIN Company, Inc. 457-9 E. Water St. Milwaukee, Wis.

r Best Paying Page

e with- NITRAGIN -With 100% Profit

Restores and Maintains Soil Fertility

Use Your Catalog for NITRAGIN:

unter and catalog space for selling seed. For your own profit you
catalog space for NITRAGIN.

OUR HALF PAGE: (No. 10)

r

FARMER
r big point
Your profit
is because
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logues.

LARGER CROPS in FIELD and GARDEN

If you use

NITRAGIN

Restores and Maintains Soil Fertility

Registered in the United States Dec. 6th, 1898. 25 YEARS AGO.

Awarded Gold Medal World's Fair - St. Louis 1904. 19 YEARS AGO.

Alfalfa, clovers, soybeans, cowpeas, beans, peanuts and other legumes should always be inoculated with Nitragin. The use of necessary bacteria, in the soil is often the cause of a poor legume crop. A good inoculation is also

A Great Price Reduction

NITRAGIN Costs Less

Nitragin now comes in Bushel sizes instead of acre sizes. This means that it only costs one cent per bushel for inoculation. If you sow 1 pound to the acre it will cost you 10 cents for your Nitragin. It means this:

Your Dollar Goes Further With NITRAGIN

Nitragin is an old, reliable inoculation. At the low rates of 40 to 60 cents per acre you cannot afford to sow legumes without it. Nitragin is sold by all the leading seedsmen, in a form suitable to your soil. Ask your dealer for Nitragin. Refuse to buy other stocks. Keep to us.

EVERY GARDEN NEEDS NITRAGIN

New Garden Culture for Peas and Beans
See Below

PRICES

½ Bushel size	40c	Postage 5c
¼ Bushel size	25c	Postage 3c
1 Bushel size	$1.75	Postage 7c
5 Bushel size	$7.75	Postage 40c
Garden (peas, beans, sweet corn - One to new package)	25c	Postage 3c

STATE WHAT CROP YOU WANT THE NITRAGIN FOR

PRICES

GARDEN SIZE

For Peas, Sweet Peas and Beans (5 in each). Sent in neatly decorated cartons for Garden Packet. 1 pound in each carton.

Wholesale	Retail	Consumer
[illegible]	[illegible]	[illegible]

F. O. B. Milwaukee

Milwaukee, Wis.

DIMENSIONS OF ADS

These full page and half page forms are electros. Order them by number. They are [illegible] Inches. We have these [illegible] special ruled pages:

No. 10	Full page—4½ in. wide by 6½ in. deep
No. 20	Full page—4½ in. wide by 3 in. deep
No. 30	Full page—7 in. wide by 3 in. deep
No. 40	Half page—4½ in. wide by 3½ in. deep
No. 50	Half page—4½ in. wide by 3 in. deep
No. 60	Half page—3½ in. wide by 4½ in. deep
No. 70	Half page—3 in. wide by 4 in. deep
No. 80	Half page—4½ in. wide by 2½ in. deep

478-479

DEFTS. EX. 11-A IDEN.

DEFTS. EX. 11-B IDEN.

DEFTS. EX. 11-C IDEN.

DEFTS. EX. 11-D IDEN.

DOES ONE SPECIES OF LEGUME BACTERIA PRODUCE AN INHIBITORY EFFECT 482-483
ON ANOTHER SPECIES WITHIN THE SAME CULTURE?

In August, 1944, a greenhouse experiment was planned with several objects in view: (1) to test the nitrogen-fixing efficiency of five strains of alfalfa bacteria, Rhizobium meliloti, on alfalfa plants, and (2) to determine if there exists any antagonism or possible inhibition of nitrogen fixation between Rhizobium meliloti and Rhizobium trifolii when grown in the same culture.

The history of the alfalfa strains used in this study follows:

Strain No.	Source of Strain	Date Obtained
3DOa1	Commercial Farmogerm Culture	1912
3DOa7	Alfalfa Nodule Caledonia, Minnesota	1932
3DOa10	Nitragin Collection Formerly No. 103	1926
3DOa12	U. S. D. A. Strain No. 436	1928
3DOa15	O. A. C. Alfalfa Strain Dr. Halverson	1928

The history of the red clover strains used in this study follows:

Strain No.	Source of Strain	Date Obtained
3DOk1	Red Clover Nodule Near Sterling, Ill.	1934
3DOk4	Red Clover Nodule Caledonia, Minnesota	1932
3DOk5	Red Clover Nodule, Illinois	193 4
3DOk7	Red Clover Nodule, Michigan	1934
3DOk13	Red Clover Nodule, Wisconsin	1935

EXPERIMENTAL

A pure culture of each single strain was inoculated into 250 c.c. of yeast-mannitol liquid No. 79 on September 1, 1944. On September 8, 1944, single strain humus cultures were prepared by mixing 40 c.c. of each liquid suspension of bacteria with 50 gms. 200 mesh dried and partially sterilized humus and 12.5 gms. finely ground limestone to neutralize the acidity.

Mixed cultures were prepared by mixing 20 c.c. of a single strain alfalfa liquid suspension plus 20 c.c. of a composite liquid suspension of red clover bacteria with 50 gms. of humus and 12.5 gms. of limestone. This composite liquid suspension of red clover bacteria was prepared by mixing together 50 c.c. of liquid from each of the five pure culture suspensions of red clover bacteria, making a total of 250 c.c. of this composite liquid.

The culture treatments used in this experiment were as follows:

No. 1 Single strain alfalfa No. 3DOa1
No. 2 Single strain alfalfa No. 3DOa1 plus red clover bacteria
No. 3 Single strain alfalfa No. 3DOa7
No. 4 Single strain alfalfa No. 3DOa7 plus red clover bacteria

DEPTS. EX. 13 IDEN.

Defendants
Exhibit No. 13
T. B. D.

No. 5 Uninoculated controls
No. 6 Composite mixture of all five single strain alfalfa bacteria
No. 7 Composite mixture of all five single strain alfalfa bacteria plus composite mixture of five single strains of red clover bacteria
No. 8 Single strain alfalfa No. 3D0a10
No. 9 Single strain alfalfa No. 3D0a10 plus red clover bacteria
No. 10 Single strain alfalfa No. 3D0a12
No. 11 Single strain alfalfa No. 3D0a12 plus red clover bacteria
No. 13 Single strain alfalfa No. 3D0a15
No. 14 Single strain alfalfa No. 3D0a15 plus red clover bacteria

One-half gallon earthenware glazed pots were prepared as shown in Figure 1. A layer of coarse gravel was first added, the watering tube put in place, washed bank sand was added next and the sand was thoroughly moistened with Bryan's modified Crone's solution. Each pot was covered with wrapping paper tied and sterilized in the autoclave for five hours at 15 lbs. pressure.

The alfalfa seeds were first freed of legume bacteria and a sufficient number inoculated with each culture treatment to plant five pots. Planting of the alfalfa was done on September 25. After planting a thin layer of fine gravel was put on top of the sand in each jar to reduce chances for contamination. Extreme care was exercised in watering; sterilized distilled water was added when needed and at 30-day intervals more sterilized Crone's solution was added.

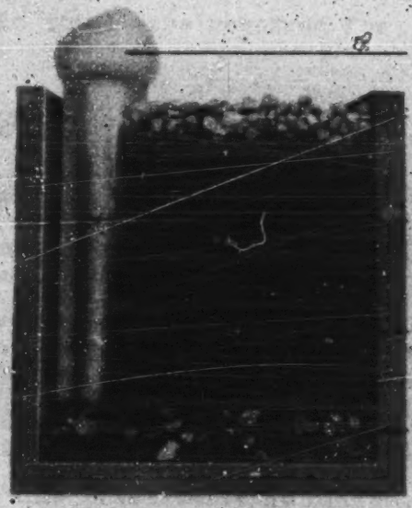

Figure 1

The plants were photographed on January 9, 1945, and harvested on January 18, 1945. The roots were washed free of sand and the whole plants from each pot were dried, weighed, ground, and samples analyzed for total nitrogen by the standard Kjeldahl method.

RESULTS

A complete set of pictures obtained in this experiment is attached hereto. A careful study of each picture would tend to disprove the statement that "it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen-fixation by the plant and the organism was inhibited or even prevented."

Since one of the main objects of this experiment was to determine any possible inhibitive effect of the red clover bacteria on the nitrogen-fixing ability of the alfalfa strains, the data obtained from the total nitrogen determinations were subjected to a critical statistical analysis.

The results of this analysis are as follows:

		3D0a1	3D0a7	3D0a10	3D0a12	3D0a15	Mixture 5Strains	Total
Alfalfa	ΣX	108.2	123.0	145.8	135.3	133.1	142.2	787.6
	ΣX^2	2,476.96	3,088.06	4,355.02	3,756.73	3,593.29	4,236.7	
Alfalfa plus Red Clover	ΣX	132.1	161.3	144.9	152.2	151.0	177.0	898.5
	ΣX^2	3,525.81	5,556.85	4,223.89	4,787.70	3,488.92	6,329.52	
Total		240.3	284.3	290.7	287.5	284.1	319.2	1,686.1
Difference		23.9	38.3	.7	16.9	2.1	34.9	5%= 33.5

A difference of 33.5 between strain totals are required for statistical significance.

CONCLUSIONS

The conclusions, which may be drawn from these data, are:

(1) An over-all comparison between strains used singly in mixtures of alfalfa strains and alfalfa strains plus red clover strains is significant in favor of the alfalfa strains plus red clover strains mixture.

(2) Alfalfa strain No. 3D0a7 at the 5% level is significantly better when mixed with red clover strains that when used singly. Mixtures of five strains of alfalfa bacteria plus five strains of red clover bacteria are significantly better than the five strains of alfalfa alone.

(3) Alfalfa strains Nos. 3D0a1 and 3D0a12 show an apparent beneficial result.

(4) Alfalfa strains Nos. 3D010 and 3D0a15 show practically no difference between the use of the composite and the single culture.

(5) These data strongly support the fact that strains from different cross-inoculation groups--namely, the alfalfa and clover groups--can be mixed and grown together and that no inhibitive effect is demonstrated when they are mixed.

(6) The set of pictures offer strong evidence to support conclusion No. 5.

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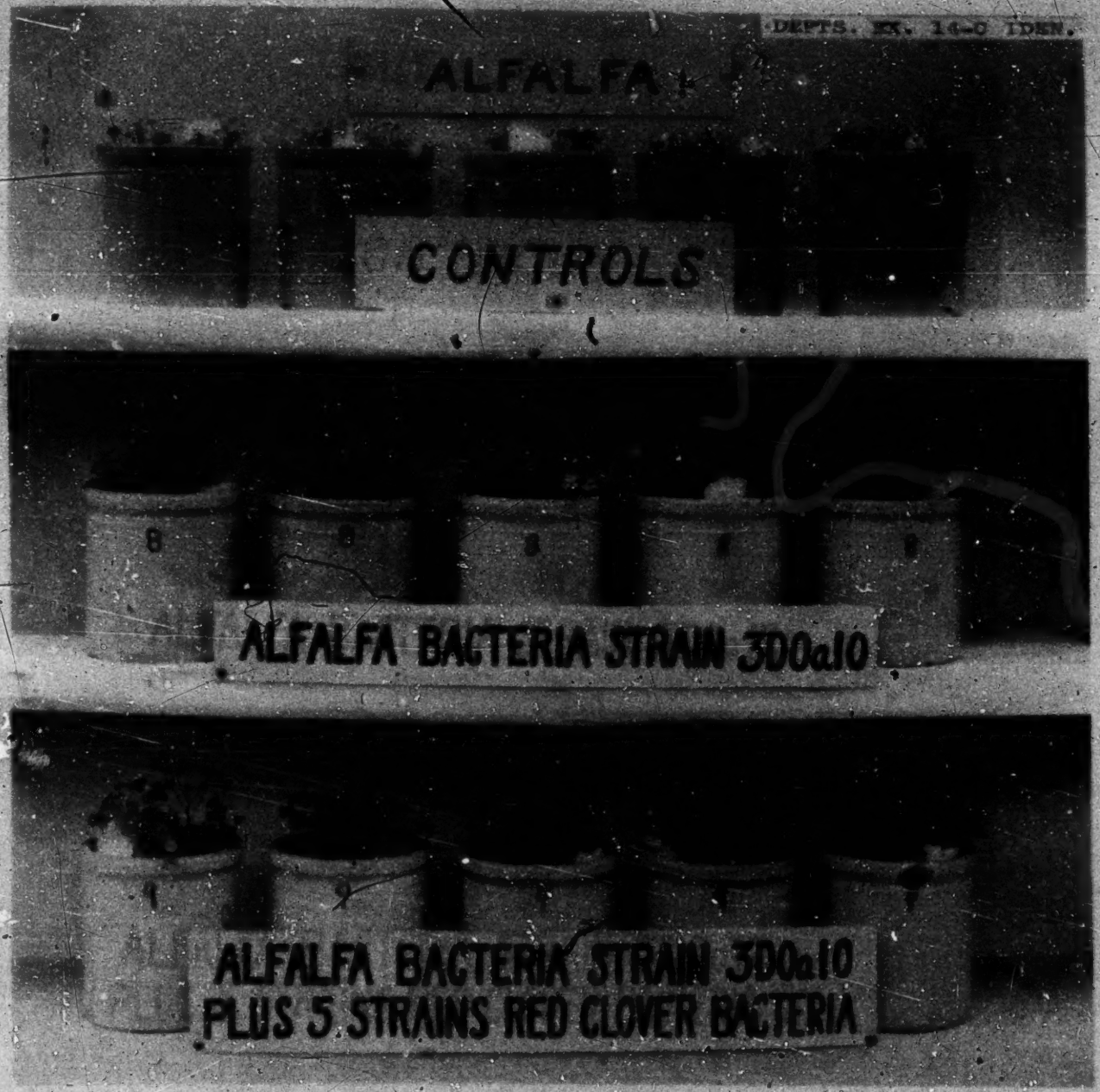
DEFTS. EX. 13 IDEN.

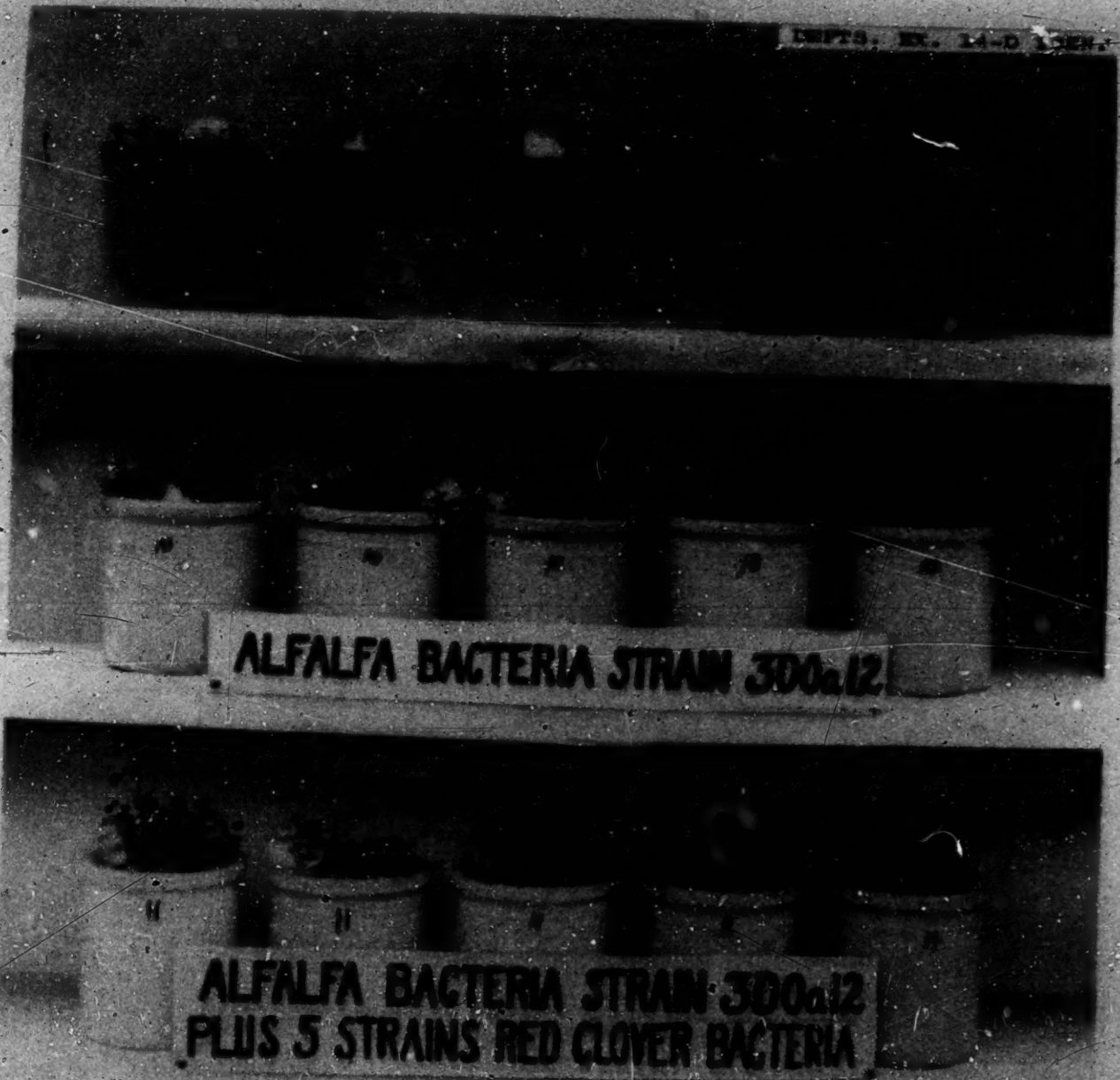
DEPTS. EX. 14-A IDEN.

488-489

ALFALFA
CONTROLS
ALFALFA BACTERIA STRAIN 3D0a7
ALFALFA BACTERIA STRAIN 3D0a7
PLUS 5 STRAINS RED CLOVER BACTERIA

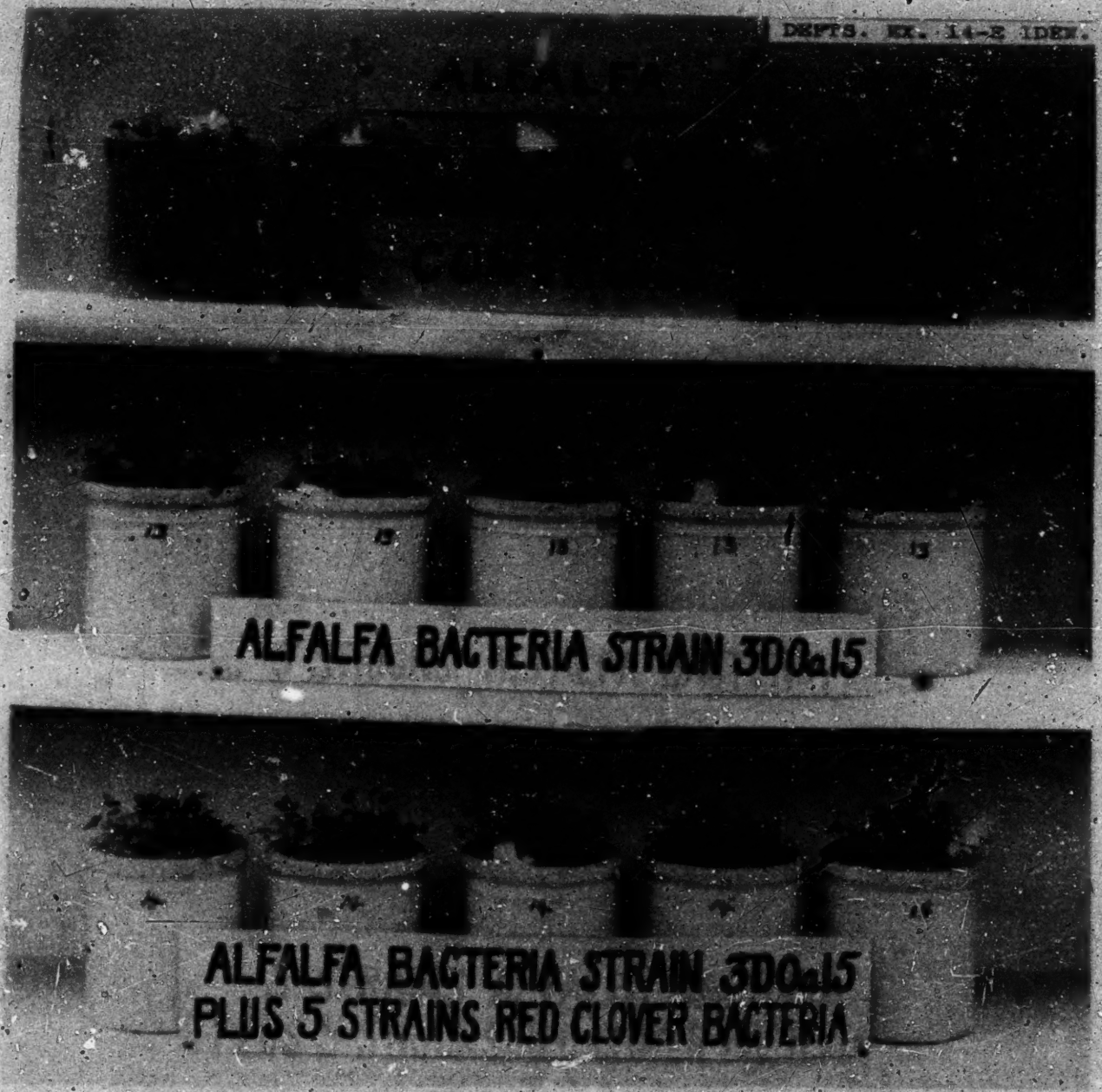

DEPTS. EX. 14-C IDEN.
ALFALFA
CONTROLS
ALFALFA BACTERIA STRAIN 3D0a10
ALFALFA BACTERIA STRAIN 3D0a10
PLUS 5 STRAINS RED CLOVER BACTERIA
492-403

DEPTS. EX. 14-D 1 DEN.



494-495

DEPTS. EX. 14-2 IDEN.



496-497

ALFALFA
CONTROLS
5 STRAINS ALFALFA BACTERIA
5 STRAINS ALFALFA BACTERIA
PLUS 5 STRAINS RED CLOVER BACTERIA

498-490

927

DEFENDANT'S EXHIBIT 15-A.

EXPERIMENT NO. 1—CRIMSON CLOVER

Sept. 22 to Jan. 7, 1938

Culture No.	Dry Weight grams	Percentage Nitrogen	Total Nitrogen
3DOQ1(a)	9.25	1.24	115.6*
3DOQ2(a)	6.25	1.18	74.0
3DOQ2(c)	8.00	1.28	102.5
3DOQ2(d)	7.50	1.32	99.0
3DOQ2(e)	8.00	1.63	130.9
Control	1.25	.94	1.2

* Each datum based on 20 plants

928

CRIMSON CLOVER—Trifolium incarnatum

Oct. 19, 1939 to Jan. 20, 1940

Strain	Dry Weight 36 pl. gms.	Percentage Nitrogen	Total Nitrogen mgms.
3DO11	3.54	1.80	63.6
3DOY1	4.41	2.08	93.9
3DOM5	1.61	1.68	27.9
3DOK4	3.09	1.80	55.5
3DOK7	1.39	1.40	19.5
3DOK5(a)	4.58	2.08	95.5
3DOK13	1.45	1.40	20.0
3DOK21	3.15	1.60	50.5
3DOK23	1.93	1.16	22.4
3DOK24	1.76	1.14	20.0
3DOQ1(a)	4.20	1.92	80.6
3DOQ2(c)	3.60	1.96	70.7
Control	1.14	1.24	14.1
Control	1.27	1.28	16.3

Strain	Host-plant	Source	Date
3DO11	Alsike clover		
3DOY1	McNeill Clover		
3DOM5	White clover		
3DOK4	Red clover		
3DOK7	" "		
3DOK5(a)	" "		
3DOK21	" "		
3DOK23	" "		
3DOK24	" "		
3DOQ1(a)	Crimson clover		
3DOQ2(c)	Crimson clover		

929 DEFENDANT'S EXHIBIT 15-B.

RED CLOVER—Trifolium pratense

Oct. 18, 1939 to Jan. 15, 1940

Strain	Dry Weight 36 pl. gms.	Percentage Nitrogen	Total Nitrogen mgms.
1DO11	2.76	1.82	50.0
1DOY1	.84	.75	11.1
1DOM5	2.94	1.82	54.9
1DOK4	2.50	1.88	66.0
1DOK7	2.54	1.74	61.5
1DOK5(a)	2.90	1.02	79.0
1DOK13	1.23	1.40	17.9
1DOK31	3.59	1.80	64.5
1DOK29	4.14	1.80	74.5
1DOK24	1.07	1.20	12.3
1DOQ1(a)	3.86	1.90	69.5
1DOQ2(c)	3.96	1.92	76.0
Control	.97	.76	11.5
Control	1.04	1.40	14.8
Control	1.07	1.02	10.9

Strain	Host-plant
1DO11	Alsike clover
1DOY1	McNeill clover
1DOM5	White clover
1DOK4	Red clover
1DOK7	" "
1DOK5(a)	" "
1DOK13	" "
1DOK31	" "
1DOK29	" "
1DOK24	" "
1DOQ1(a)	Crimson clover
1DOQ2(c)	Crimson clover

930 DEF. EX. 15-B.

EXPERIMENT NO. 1—RED CLOVER

Sept. 21 to Dec. 14, 1937

Culture No.	Dry Weight grams	Percentage Nitrogen	Total Nitrogen
3DOK1(a)	5.0	2.62	131.0*
3DOK2	2.0	2.92	58.4
3DOK3(37a)	2.5	3.18	79.5
3DOK5(a)	4.0	2.64	106.7
3DOK6	2.0	3.08	61.5
3DOK7	5.5	2.76	151.8
3DOK8	4.0	2.84	114.0
3DOK12	4.5	2.74	123.8
3DOK13	5.0	3.20	160.0
3DOK14	4.0	2.80	112.0
3DOK15	.3	1.36	4.0
3DOK16	1.2	2.50	30.0
3DOK19	2.5	2.80	70.0
3DOK18	3.0	2.94	88.0
3DOK20	.2	1.21	2.6
Control	.2	1.18	2.4
Control	.2	1.27	2.5

* Each datum based on 10 plants.

931 DEFENDANT'S EXHIBIT 15-C.

TABLE 3

NITROGEN FIXATION BY TWENTY STRAINS OF R. MELILOTI ON ALFALFA, BURR CLOVER AND SWEET CLOVER

Oct. 15 to Dec. 10, 1926

	Alfalfa		Burr Clover		Sweet Clover	
Strain	Dry Weight	Total Nitrogen	Dry Weight	Total Nitrogen	Dry Weight	Total Nitrogen
3DOa1	1.6	49.0	.3	5.0	2.5	82.5
	1.6	44.0	.4	4.2	2.6	83.6
	1.3	30.0	.4	4.5	2.6	79.4
	4.5	114.0	1.1	13.8	7.7	245.6
3DOa7	1.1	27.5	.3	3.1	2.3	68.5
	2.7	67.5	.3	4.1	2.7	95.0
	2.7	74.0	.3	3.7	2.9	100.0
	6.5	169.0	.7	8.9	8.3	293.5
3DOa10	2.3	62.0	.4	3.1	3.1	109.0
	3.0	81.0	.3	4.3	3.4	114.0
	2.5	75.0	.3	3.8	3.3	111.0
	7.7	219.0	1.0	11.2	9.3	334.0
3DOa12	2.4	67.0	.4	3.8	3.5	107.0
	3.4	89.1	.4	5.0	3.5	125.0
	3.1	80.4	.3	3.5	2.9	99.8
	8.9	236.5	1.0	12.3	9.9	331.6
3DOa14	2.3	64.1	.3	4.0	2.9	95.0
	2.6	71.0	.3	3.3	3.0	93.4
	2.3	63.5	.3	4.1	2.6	88.5
	7.3	198.6	.8	12.0	8.5	275.9
3DOa15	2.8	80.5	.3	3.3	1.3	43.0
	2.6	74.0	.3	4.0	.8	27.0
	2.5	74.0	.3	3.6	1.6	48.0
	7.9	228.5	.8	11.4	3.8	128.0
3DOa17	2.0	56.5	.3	3.9	2.1	68.0
	1.9	55.5	.4	3.7	1.7	39.0
	2.0	60.0	.3	4.6	1.8	41.0
	5.9	172.0	.9	12.5	5.4	186.0
3DOa26	.3	3.3	.3	3.4	.3	3.3
	.5	4.1	.5	4.0	.2	2.4
	.5	3.9	.3	5.2	.4	5.1
	1.3	11.3	.8	12.5	.9	11.3
3DOa1(a)	2.3	65.0	1.7	47.3	.8	9.4
	2.6	69.0	1.8	46.5	1.1	12.3
	1.9	59.3	1.8	51.8	.8	10.9
	6.8	193.3	5.3	145.0	2.5	32.6
3DOa1(d)	1.9	47.7	1.1	31.4	2.5	93.3
	2.4	67.0	1.2	35.9	2.6	75.0
	2.0	53.5	1.1	30.2	2.4	75.0
	6.3	167.3	3.5	97.5	7.5	223.5
3DOC1	2.1	57.0	.3	3.4	.3	17.7
	1.8	49.7	.3	4.1	1.1	30.1
	2.6	64.0	.3	5.0	1.0	18.3
	6.5	170.7	.8	12.5	3.0	66.1

932

TABLE 3 (Continued)

Strain	Alfalfa Dry Weight	Alfalfa Total Nitrogen	Burr Clover Dry Weight	Burr Clover Total Nitrogen	Sweet Clover Dry Weight	Sweet Clover Total Nitrogen
3DOC2	1.2	18.7	2.2	48.5	1.0	22.0
	1.5	12.2	1.7	50.5	1.4	29.0
	1.3	13.4	1.7	49.3	1.2	31.0
	4.0	44.3	5.7	143.1	3.6	82.0
3DOC3	1.0	20.0	.9	21.0	2.7	77.0
	.8	17.0	1.1	27.6	1.9	58.0
	1.1	20.4	.8	18.9	1.8	60.0
	2.7	57.4	2.8	67.5	6.4	195.0
3DOd2	1.5	37.0	1.4	43.5	2.2	54.5
	1.9	43.2	1.4	40.5	2.1	76.0
	1.6	32.0	1.6	45.7	2.3	81.0
	5.0	112.2	4.4	129.7	6.6	241.5
3DOh1	2.4	67.0	.3	7.7	2.3	83.0
	2.1	59.0	.4	8.7	2.5	96.0
	2.2	62.0	.3	8.5	2.0	87.0
	6.7	188.0	1.0	24.9	6.8	266.0
3DOh3	2.6	57.0	.3	3.7	2.7	86.5
	2.7	63.0	.3	4.0	3.1	98.0
	2.0	54.2	.3	5.0	2.6	78.0
	7.3	179.2	.8	12.7	8.4	262.5
3DOh7	1.6	46.0	.3	3.6	3.1	50.0
	1.8	48.0	.3	2.5	2.6	100.0
	2.2	55.0	.3	4.2	3.0	102.0
	5.6	149.0	.8	10.3	9.7	252.0
3DOh8(a)	1.3	33.2	.2	3.6	2.3	39.0
	1.7	41.5	.3	5.9	1.9	69.1
	1.3	32.5	.3	3.8	2.4	77.0
	4.3	107.2	.8	13.3	6.6	235.1
3DOh10	1.1	12.1	.2	3.6	2.6	77.0
	1.3	14.3	.2	3.1	2.1	59.0
	1.6	13.9	.2	4.7	2.6	63.0
	4.0	40.3	.7	11.4	7.3	199.0
3DOi3	1.6	43.0	.4	4.3	2.4	85.0
	1.9	61.5	.4	5.0	2.5	87.0
	1.8	51.0	.4	2.9	2.7	85.5
	5.3	155.5	1.2	13.2	7.6	257.5
Control	.9	4.3	.4	4.2	.4	5.3
	1.1	7.5	.3	3.0	.3	4.3
	.8	6.1	.2	8.4	.3	4.2
	2.8	17.9	.9	10.6	1.0	14.2
Control	1.3	5.9	.3	3.5	.3	3.6
	.9	8.1	.3	3.4	.4	4.3
	.9	8.5	.2	3.0	.4	5.4
	3.0	22.5	.8	9.9	1.0	13.3

Each datum based on 10 plants.

TABLE 8

NITROGEN FIXATION BY TWENTY STRAINS OF R. MELILOTI ON ALFALFA, BURR CLOVER AND FENUGREEK

Feb. 10 to April 17, 1939

Experiment 8

Strain	Alfalfa		Burr Clover		Fenugreek	
	Dry Weight	Total Nitrogen	Dry Weight	Total Nitrogen	Dry Weight	Total Nitrogen
3DOA3	2.1	82.8	.3	3.3	.4	5.4
	2.1	84.0	.3	3.4	.4	5.4
	2.1	82.0	.4	4.3	.4	4.9
	6.3	102.5	1.0	11.1	1.3	15.7
3DOA2	1.3	82.3	.3	3.3	.4	5.4
	1.3	81.4	.3	3.0	.4	4.8
	1.3	81.9	.3	3.7	.4	4.5
	3.7	95.7	.3	9.9	1.3	14.7
3DOA7	1.3	80.4	.3	3.7	.4	4.1
	1.6	85.3	.3	4.3	.3	4.3
	1.4	82.8	.3	4.6	.3	4.8
	4.3	90.4	.3	12.1	1.0	12.9
3DOA15	1.3	81.0	.3	3.0	.3	5.3
	1.4	85.8	.4	3.4	.4	4.6
	1.5	86.9	.4	4.7	.3	3.7
	4.1	104.7	1.1	11.1	1.4	13.4
3DOA17	.7	17.3	.4	3.6	.3	4.7
	.9	22.2	.4	3.0	.4	4.4
	.9	20.6	.3	4.3	.4	5.3
	2.5	61.1	1.1	11.5	1.3	14.3
3DOA36	.3	3.6	.4	3.0	.3	3.0
	.3	4.3	.3	4.6	.3	5.3
	.3	3.7	.3	3.0	.3	3.4
	.9	11.6	.9	13.0	.9	13.6
3DOb3	1.1	24.3	.3	4.3	.4	4.3
	1.3	34.0	.3	3.0	.4	4.1
	1.3	41.0	.3	4.3	.4	4.3
	4.7	101.0	.3	12.1	1.3	13.6
3DOb7	1.7	33.0	.3	3.3	.4	4.6
	2.3	33.0	.4	3.3	.4	3.3
	2.4	34.0	.3	4.3	.4	3.6
	8.0	104.0	1.0	12.3	1.3	13.3
3DOb3(a)	1.3	40.3	.3	3.7	.3	4.6
	2.3	44.0	.3	4.3	.4	3.3
	1.3	41.3	.3	3.1	.4	5.3
	6.7	105.3	1.1	13.7	1.4	15.1
3DOb10	.7	14.0	.4	3.7	.3	4.3
	.3	16.0	.4	4.3	.3	4.3
	.3	16.3	.3	4.3	.3	4.7
	2.3	46.3	1.1	12.0	1.3	14.0
3DOe1(a)	2.1	48.3	1.3	44.3	1.3	23.3
	2.3	44.3	1.7	38.3	1.3	25.0
	1.3	41.3	1.4	41.3	1.4	26.4
	6.3	134.3	4.4	124.3	4.1	103.3

924

TABLE 5 (Continued)

	Alfalfa		Burr Clover		Fenugreek	
Strain	Dry Weight	Total Nitrogen	Dry Weight	Total Nitrogen	Dry Weight	Total Nitrogen
3DOe1(d)	1.7	32.2	1.4	28.0	1.5	34.6
	1.6	34.6	1.3	40.1	1.7	37.7
	1.8	38.0	2.2	56.0	1.7	38.6
	5.1	104.8	4.9	134.1	4.9	110.8
3DOC3	1.9	36.9	1.1	32.8	.5	7.8
	1.5	34.2	1.3	36.6	.6	8.7
	1.8	37.0	1.6	37.7	.7	9.1
	5.2	108.2	4.0	106.1	1.8	25.6
3DOC4	1.0	34.6	.9	23.0	.4	6.5
	1.0	21.4	1.3	32.0	.3	5.0
	1.1	22.4	1.1	35.4	.3	4.5
	3.1	69.4	3.3	90.4	1.0	16.0
3DOd2	.8	15.9	1.4	25.3	.4	5.0
	1.3	32.0	1.3	33.0	.5	5.2
	1.4	25.4	1.5	35.0	.4	5.3
	3.4	63.3	4.2	103.3	1.3	16.0
3EOf1	2.4	49.0	1.4	31.0	1.1	20.7
	2.3	55.0	1.6	36.2	1.3	22.4
	2.6	55.0	1.5	36.0	1.5	27.7
	7.3	159.0	4.5	103.2	3.9	70.8
3EOf2	1.8	38.0	1.0	24.0	1.7	28.4
	1.8	44.0	.8	16.0	1.8	27.0
	1.6	35.2	.9	16.0	1.7	26.2
	5.2	117.2	2.7	56.0	5.2	76.6
3EOf2(b)	2.2	48.0	1.3	33.0	1.8	20.6
	1.9	50.1	1.9	47.5	1.6	30.2
	2.2	46.0	1.8	49.0	1.7	25.1
	6.3	144.1	5.0	129.5	5.1	83.0
3DOe3	2.2	38.8	.5	9.0	.3	4.8
	1.8	41.0	.5	11.4	.3	5.5
	2.1	42.0	.5	8.3	.3	4.2
	6.1	121.8	1.5	28.7	.9	14.2
3DOZ1	1.9	43.3	1.8	43.0	1.4	24.6
	1.9	40.1	1.8	41.0	1.3	27.3
	1.8	38.0	1.6	36.4	1.5	22.2
	5.6	121.4	5.2	120.4	4.2	74.7
Control	.7	13.6	.4	4.7	.4	6.4
	.6	12.7	.3	5.2	.3	5.5
	.6	15.2	.3	3.7	.3	5.0
	1.9	41.5	1.0	13.7	1.0	16.9
Control	.7	16.1	.3	3.9	.5	4.1
	.6	10.2	.3	3.0	.4	4.2
	.7	13.7	.4	4.3	.3	3.2
	2.0	40.0	.9	11.2	1.2	11.6

Each datum based on 10 plants.

508

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Agricultural

Experiment Station

A Preliminary Report on Muck Humus As a Fertilizer and Carrier of Beneficial Soil Bacteria

BY THOMAS F. MANNS AND JOSEPH M. GOHEEN

Newark, Delaware

DEFTS. EX. 16 IDEN.

60

A Preliminary Report on Muck Humus As a Fertilizer and Carrier of Beneficial Soil Bacteria

A Preliminary Report on Muck Humus as a Fertilizer and Carrier of Beneficial Soil Bacteria

By Thos. F. Manns and Joseph M. Gourley*

Within recent years practical agriculturalists over the United States have come to recognize the ease and efficiency with which muck soils lend themselves to the production of truck crops. The utilization of mucks and peats for fertilizer fillers, materials for amending the physical condition of upland soils, and their use as a direct fertilizer has likewise served to bring the consideration of such material to the foreground.

It is recognized also that there may be as much difference between soils of organic origin as between the most diversified of the mineral soils. The commercialization of deposits of different formation has also served to emphasize this point thru the highly satisfactory results obtained in some cases and the injurious effects in others.

Micro-biological studies of American soils have been confined almost exclusively to those of mineral origin, but the increasing interest in organic soils and the important rôle that micro-organisms play in them make highly legitimate a study of their activities.

The object of these investigations was to determine (1) whether high grade muck or so-called "humus," such as that found in the trucking district in northern New Jersey, when properly inoculated, would carry beneficial soil bacteria, including the nodule organisms for the different agricultural and floral legumes; also whether reinforcement and composting of the muck humus would further increase or favor a beneficial flora. (2) Further, to determine the simplest method of adding such inoculation. (3) To determine whether one compost may carry the inoculant for all the agricultural and floral legumes at the one time and be sufficiently reinforced and balanced to make a high grade soil inoculator, renovator, stimulant and fertilizer. The work necessitated a study of the flora found in the virgin muck, and the changes brought about by successive years of cul-

* Holder of research fellowship given by the Alphano Humus Co., of New York City.

tivation, and further, what organisms should be added to make the material a general and beneficial soil inoculant.

The Status of Legume Inoculation

It has been known for a number of years that the organism causing nodules on certain legumes would also produce nodules on closely related species; for example, the organism producing nodules on white sweet clover (*Melilotus alba*) and yellow sweet clover (*Melilotus officinalis*) is the same as that which works on alfalfa. This same organism also works on Indian yellow sweet clover (*Melilotus indica*), trefoil or black medick (*Medicago lupulina*), yellow alfalfa (*Medicago falcata*), burr clover (*Medicago denticulata*), spotted medick (*Medicago arabica*) and *Trigonella foenum graecum*.

It is known that in the clover group the organism which inoculates red, mammoth, white and alsike clovers (*Trifolium pratense, T. medium, T. alba, T. hybridum*) also inoculates crimson, buffalo, rabbit-foot, hop, and hop trefoil clovers (*Trifolium incarnatum, T. reflexum, T. arvense, T. agrarium, T. procumbens.*)

Likewise the organism which covers the vetch and pea group, covers the plants of the genera Vicia, Pisum and Lathyrus, including many species.

A fourth group may be known as the bean group which covers many species.

At present, soy bean (*Soja spp.*) and cow pea (*Vigna spp.*) are apparently distinct, making six specific groups covering our important American agricultural and floral legumes.

Two other groups are those including the lupines and the lotus. M. Klummer and R. Kruger*, two European workers and H. Garman and M. Didlake** of Kentucky have recently published articles showing the groups into which certain of the different legumes fall.

Using this as a basis, we have gathered inoculation representing each of the above groups for the purposes of this work.

Variations in Composition and Flora of Muck and Peat

The investigations have necessitated the study of an inferior and very acid peat, for a comparison of the acidity, the chemical analysis, and the flora. Such a comparison was made with a peat being used

*Centbl. Bakt 2 Abt 40 (1914) No. 11-13-pp. 256-265.

**Bul. 184 (1914) Agr'l Expt. Sta. Kentucky, pp. 343-363.

in the vicinity of Sumner, New Jersey, which was quite coarse and poorly decomposed.

TABLE I—Comparison of Alphano, New Jersey, muck, with peat from Sumner, New Jersey

	Alphano, N. J. muck	Sumner, N. J. peat
(1)		
Lime Requirement (per 2,000,000 lb. acre, air dry basis.)	4200 to 5300 lbs. (CaO)	12,600 to 17,000 lbs. (CaO)
Nitrogen	2.67%	1.3%
(2)		
Humus or soluble Org. matter	26.2 to 29.4	4.3—6.8
Ammonifiers, per gram, dry basis.	50,000—260,000	33,333
(3)		
Nitrifiers, per gram dry basis.	10,000— 33,000	None.
(4)		
Azotobacter, per gram, dry basis.	20,000— 66,000	Trace.
(5)		
B. radicicola, per gram dry basis.	50,000—133,000	Trace.
Various moulds,	50,000—133,000	Trace.

(1) Lime requirement by the saturated calcium acetate method mentioned in a paper read before section C (Chem.) of the American Association for the Advancement of Science, Philadelphia, Pa., Dec. 31, 1914.

(2) Humus or soluble organic matter by the Grandeau method.

(3) By the author's medium No. 20 (see p. 37).

(4) By Ashby's medium modified with author's soil extract.

(5) By Ashby's medium—The Radicicola present were of the clover group.

Proposed Methods for Investigation

The methods proposed for carrying out, in the greenhouse, the composting, inoculation of the muck and testing for nodule production were as follows: Four gallon glazed earthen-ware jars were filled with 10,000 grams of muck containing optimum water conditions. After making the composts this amount was found to overfill somewhat the jars, accordingly the amount placed in each jar was 8,000 grams. In making the composts, the muck was used in about the condition it is piled; that is, containing about 65% moisture. All composts were computed on a ton basis. With the exceptions of the com-

posts numbers 9, 10, 11, 12, and 13 to which cyanamid was added and 23 and 24 to which guano was added, no nitrogen was used, excepting the small amount contained in the soil required for inoculation. Inoculation was carried out by using soil containing a well balanced flora including the nodule organisms of the different groups of valuable agricultural and floral legumes.

The inoculated soil was added in the proportion of 25 lbs. per ton of muck. A stimulant to increase certain groups of soil flora was added in the form of a crude carbohydrate, at the rate of 30 lbs. per ton, except in composts Nos. 2B, 3B, 4B, 5B, 6B, 7B and 8B, where 60 lbs. per ton were used.

In measuring inoculation or the efficiency of the compost for nodule production, four of the most important groups of legumes were grown in each compost,—viz., cow peas—soy beans—alfalfa and crimson clover, and a careful study made of the roots. Further, to study the value of the compost as a general soil inoculator, an inoculation in sterilized sand was carried out, using the compost in different amounts on a two million pound acre basis, viz., two lbs., 100 lbs. and 500 lbs. Five different legumes were employed, each representing an individual group, viz., alfalfa, red clover, winter vetch, cow peas and soy beans. To obtain data on the availability of nitrogen, a growth of rye and millet was used. Some chemical data were taken on nitrates which showed marked variations in the different composts. The fluctuations and variations in the flora were studied by plate cultures, using media that were adapted to bring out the more important physiological groups, such as the ammonifiers, the nitrifiers and the azotofiers, including *B. radicicola*. In making notes on the flora, only radical or marked changes were recorded.

Data for Building Composts

In order to build neutral composts from various alkaline, acid and neutral products such as the commercial phosphates, unleached hard wood ashes, cyanamid, various carbonates, lime, etc., when added to humus, the following experiments were carried out; various quantities of lime were added to the humus from Alphano, New Jersey to determine amounts required to neutralize the product. It was found that 4.5 to 7 pounds of calcium oxide will completely neutralize a ton on an air dry basis; that one pound of CaO will neutralize five pounds of 14% commercial acid phosphate. It was found that cyana-

mid is very caustic, equalling lime, and that one pound of cyanamid will neutralize five pounds of commercial 16% acid phosphate. One-tenth pound of CaO will neutralize one ton of sheep manure, and .11 pound of CaO will neutralize a ton of dried blood; one pound of unleached hard wood ashes (chestnut) will neutralize five pounds of commercial 16% acid phosphate. It requires about one pound of Thomas slag to neutralize one pound of commercial 16% acid phosphate.

From the above data, some 40 different composts have been made, running to extremes both on the basic and acid sides.

The Flora of Humus from Alphano, N. J.

The studies have been carried out on muck from a composite of the first four feet in digging. It is to be expected that on a muck that has been used for trucking purposes for two or three seasons prior to digging, many of the beneficial soil organisms will be present and active. On the trucking areas and the dikes at Alphano, clover plants showing an abundant inoculation with the nodule organism were observed. Under such conditions, it would be expected that some *B. radicicola* of the clover group would be present. This was shown to be true by the clover grown in the non-inoculated jars—A, B, and No. 29. (See Plate III). The non-inoculated muck showed no sign of the nodule organisms for cow peas, soy beans, alfalfa and vetch.

Plate cultures made with the various media used in these experiments showed that *B. radicicola* of the clover group was present, varying from 50,000 to 133,000 per gram of moist peat. Various azotobacters were present varying in number from 20,000 to 66,000. The nitrifying organisms were the lowest of all in number, varying from 10,000 to 33,000 per gram of moist peat. The ammonifiers were present from 50,000 to 260,000 per gram. Moulds were very plentiful, varying from 50,000 to 260,000.

A rich and well balanced soil flora would show all these organisms increased by ten to fifty fold, excepting the moulds which in neutral soils are not very plentiful. In the light sandy soils of lower Delaware, moulds to the number of 100,000 per gram of moist soil, have been taken. From sick soil in North Dakota *Fusarium lini*, the fungus causing flax wilt, has been taken to the extent of 45,000 colonies per gram of moist soil.

TABLE II—*Showing Nature of Compost, Amount of Nodule*

11/17/15: Started following composts		11/20/15: Planted this date: cow peas, soy beans, crimson clover and alfalfa. 1/11/16: All plants removed and nodules and growth observed.	
		Nodules	*Growth*
A			
Humus	2,000 lbs	Cow peas	none	good
		Soy beans	"	"
		Crim. clover	many	"
		Alfalfa	few (see Comp. No. 29)	"
B			
Humus	2,000 lbs.	Cow peas	none	good
Carbohydrate	30 "	Soy beans	"	"
		Crim. clover	few	"
		Alfalfa	none	"
C			
Humus	2,000 lbs.	Cow peas	none	good
Inoc. soil	25 "	Soy beans	"	"
		Crim. clover	many	"
		Alfalfa	some	"
D			
Humus	2,000 lbs.	Cow peas	none	good
Carbohydrate	30 "	Soy beans	some	"
Inoc. soil	25 "	Crim. clover	"	"
		Alfalfa	few	"
No. 1A			
Humus	2,000 lbs	Cow peas	none	slightly chlorotic
Acid Phos. (16%)	50 "	Soy beans	"	slightly chlorotic
$Ca(OH)_2$	20 "			
Organic ash	100 "	Crim. clover	few, scattered	slightly chlorotic
Carbohydrate	30 "			
Inoc. soil	25 "	Alfalfa	good, scattered	slightly chlorotic
No. 1B			
Humus	2,000 lbs.	Cow peas	none	chlorotic
Acid Phos. (16%)	50 "	Soy beans	"	"
Organic ash	200 "	Crim. clover	very few	"
Carbohydrate	30 "	Alfalfa	good	"
Inoc. soil	25 "			

Production, Growth of Legumes and Notes on the Bacterial Flora.

1/14/16: Replanted all composts with cow peas, soy beans, crimson clover and alfalfa. 3/30/16: Pulled all plants to study nodules and growth.

Study of flora on media Nos. 22, 23, 42, 43A, 43B, 44A, 44B, 45A,45B, and 46.

Nodules	*Growth*	*Notes on Bacterial flora*
well scattered	good	Used last six media above. *B. radicicola* very few,—many fungi—flora low in all media.
none	"	
general	"	
general	"	
well scattered	good	Flora fairly good—some Azotobacters; some *B. radicicola*—no molds.
slight	"	
quite general	"	
scattered	"	
well inoculated	good	Very poor flora; few *B. radicicola*, like A.
quite general	"	
abundant	"	
quite general	"	
some inoc.	good	Flora good—*B. radicicola* plentiful. However, nothing like as plentiful as in No. 8A, No. 8B, et al. Much the best check.
general	"	
very good	"	
very good	"	
good	good	Not an abundant flora—some Azotobacters and *B. radicicola*
none	"	
few	"	
good	"	
none	fair	Many Azotobacters; not many *B. radicicola*.
none	"	
few, but large	good	
few, but large	good	

TABLE II—(Continued).

11/17/15: Started following composts		11/20/15: Planted this date: cow peas, soy beans, crimson clover and alfalfa. 1/11/16. All plants removed and nodules and growth observed.		
			Nodules	*Growth*
No. 2A		Cow peas	some	good
Humus	2,000 lbs.			
Organic ash	100 "	Soy beans	"	"
Carbohydrate	30 "	Crim. clover	few	"
Inoc. soil	25 "	Alfalfa	good	"
No. 2B		Cow peas	none	poor
Humus	2,000 lbs.			
Organic ash	200 "	Soy beans	"	"
Carbohydrate	60 "	Crim. clover	"	good
Inoc. soil	25 "	Alfalfa	good	good
No. 3A		Cow peas	none	chlorotic
Humus	2,000 lbs.	Soy beans	none	"
Carb. of potash	50 "	Crim. clover	few	"
Acid Phos.	50 "	Alfalfa	fair	"
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 3B		Cow peas	(no growth—Carbonate of Potash too	
Humus	2,000 lbs.			
Carb. of Potash	100 "	Soy beans	strong)	"
Acid Phos.	50 "	Crim. clover		"
Carbohydrate	60 "	Alfalfa		"
Inoc. soil	25 "			
No. 4A		Cow peas	none	roots not good
Humus	2,000 lbs.			
Carb. of Potash	15 "	Soy beans	"	roots not good
Calcium Carbonate	10 "			
Acid Phos.	50 "	Crim. clover	abundant	good
Carbohydrate	30 "			
Inoc. soil	25 "	Alfalfa	"	good
No. 4B		Cow peas	none	none
Humus	2,000 lbs.			
Carb. of Potash	30 "	Soy beans	"	none
Calcium Carbonate	20 "			
Acid Phos.	50 "	Crim. clover	no inoc.	poor
Carbohydrate	60 "			
Inoc. soil	25 "	Alfalfa	good inoc.	fair

TABLE II—(Continued).

1/14/16: Replanted all composts with cow peas, soy beans, crimson clover and alfalfa. 3/30/16: Pulled all plants to study nodules and growth.		Study of flora on media Nos. 22, 23, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.
Nodules	*Growth*	*Notes on Bacterial flora*
good	fair	Some few *Az. chroococcum* and many other Azotobacters. Many *B. radicicola.*
few	"	
few	good	
few	"	
none	fair	An abundant flora—many *B. radicicola* and *Azotobacters*
"	"	
"	poor	
good	"	
none	very poor	Many Azotobacters—few *B. radicicola*—a fairly good flora.
"	" "	
"	" "	
"	" "	
none	very poor	Some Azotobacters, but not as many as No. 3A.
"	almost no growth	
"	" " "	
"	" " "	
fairly good	fair	Many *B. radicicola, many* Azotobacters—fairly good flora.
" "	"	
very good	good	
splendid	"	
none	plants poor	An abundant flora. Many Azotobacters and many *B. radicicola.*
"	"	
some	" "	
none	" "	

TABLE II—(Continued).

11/17/15: Started following composts

No. 5A	
Humus	2,000 lbs
Potassium Carb.	30 "
Acid Phos.	50 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 5B	
Humus	2,000 lbs
Potassium Carb.	60 "
Acid Phos.	50 "
Carbohydrate	60 "
Inoc. soil	25 "
No. 6A	
Humus	2,000 lbs
Sodium Carb.	30 "
Acid Phos.	50 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 6B	
Humus	2,000 lbs
Sodium Carb.	60 "
Acid Phos.	50 "
Carbohydrate	60 "
Inoc. soil	25 "
No. 7A	
Humus	2,000 lbs
Thomas slag	200 "
Carbohydrate	30 "
Inoc. soil	25 "

11/20/15: Planted this date: cow peas, soy beans, crimson clover and alfalfa. 1/11/16: All plants removed and nodules and growth observed.

	Nodules	*Growth*
Cow peas	none	good
Soy beans	some	"
Crim. clover	abundant	"
Alfalfa	abundant	good
Cow peas	none	poor
Soy beans	"	poor
Crim. clover	quite abundant	quite healthy
Alfalfa	inoc. good	quite healthy
Cow peas	none	poor
Soy beans	"	"
Crim. clover	abundant	healthy
Alfalfa	"	"
Cow peas	(No growth—Sodium carbonate too strong.)	
Soy beans		
Crim. clover		
Alfalfa		
Cow peas	quite abundant	good
Soy beans	quite abundant	"
Crim. clover	quite abundant	"
Alfalfa	quite abundant	"

TABLE II—(Continued).

2/14/16: Replanted all composts with cow peas, soy beans, crimson clover and alfalfa. 3/30/16: Pulled all plants to study nodules and growth.		Study of flora on media Nos. 22, 23, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.
Nodules	*Growth*	*Notes on Bacterial flora*
very slight	fair	Many *Azotobacter chroococcum*, also other Azotobacters; an abundant flora, exceptionally abundant in *B. radicicola*.
poor	"	
good inoc.	good	
splendid inoc.	"	
none	fair	An abundant flora—many *Azotobacter chroococcum*, and other Azotobacters; many *B. radicicola*. A good flora.
"	"	
slight	good	
good inoc.	"	
none	poor	Many Azotobacters, tho not as abundant as in 6B.
"	"	
very slight	"	
" "	"	
no growth	no growth	Abundant *Azotobacter chroococcum*. Many urea bacteria—probably *B. fluorescens*.
" "	" "	
" "	" "	
" "	" "	
splendid	good	Many Azotobacters—*B. radicicola* not abundant.
very good	"	
small and scattering	"	
" " "	"	

TABLE II—(Continued).

11/17/15: Started following composts

No. 7B	
Humus	2,000 lbs.
Thomas slag	100 "
Carbohydrate	60 "
Inoc. soil	25 "
No. 8A	
Humus	2,000 lbs.
Thomas slag	50 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 8B	
Humus	2,000 lbs.
Thomas slag	15 "
Carbohydrate	60 "
Inoc. soil	25 "
No. 9	
Humus	2,000 lbs.
Cyanamid	10 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 10	
Humus	2,000 lbs.
Cyanamid	25 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 11	
Humus	2,000 lbs.
Cyanamid	200 "
Acid Phos.	200 "
Carbohydrate	30 "
Inoc. soil	25 "

11/20/15: Planted this date: cow peas, soy beans, crimson clover and alfalfa. 1/11/16: All plants removed and nodules and growth observed.

	Nodules	*Growth*
Cow peas	none	fair
Soy beans	"	"
Crim. clover	quite abundant	"
Alfalfa	quite abundant	"
Cow peas	abundant	fine
Soy beans	"	"
Crim. clover	"	"
Alfalfa	"	"
Cow peas	many	fair
Soy beans	3 on 3 plants	"
Crim. clover	many	"
Alfalfa	"	"
Cow peas	none	healthy
Soy beans	"	"
Crim. clover	"	"
Alfalfa	few	"
Cow peas	none	none
Soy beans	none	none
Crim. clover	none	sickly
Alfalfa	"	"
Cow peas	none	none
Soy beans	none	none
Crim. clover	none	none
Alfalfa	none	none

TABLE II—(Continued).

1/14/16: Replanted all composts with cow peas, soy beans, crimson clover and alfalfa. 3/30/16: Pulled all plants to study nodules and growth.	Study of flora on media Nos. 22, 23, 39, 43A, 43B, 44A, 44B, 45A,45B, and 46
Nodules *Growth*	*Notes on Bacterial flora*
general inoc. fine	Many Azotobacters and *B. radicicola*—a good flora.
fair "	
good "	
scattered "	
good inoculation fine	A very abundant flora—many Azotobacters and many *B. radicicola*.
" " "	
scattered "	
" "	
good fine	A very abundant flora—many *B. radicicola* and Azotobacters—No. 43A is a good medium, and 43B also.
some "	
scattered "	
fair "	
none weak	An abundant fungus flora has overrun all six media.
" "	
scattered, large "	
none "	
none very weak	Same as No. 9.
" " "	
" " "	
" " "	
no growth no growth	Most abundant bacterial flora of all. Probably *B. fluorescens*.
" " " "	
" " " "	
" " " "	

TABLE II—(Continued).

1/11/16: Started following composts		1/14/16: Planted composts to cow peas, soy beans, alfalf and crimson clover. 3/30/16: Pulled all plants to study nodules and growth.		
			Nodules	*Growth*
No. 12		Cow pea	none	weak
Humus	2,000 lbs.	Soy beans	"	"
Cyanamid	10 "	Crim. clover	scattered	"
Acid Phos.	50 "	Alfalfa	"	good
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 13		Cow pea	none	weak
Humus	2,000 lbs.	Soy bean	"	"
Cyanamid	20 "	Crim. clover	"	none
Acid Phos.	100 "	Alfalfa	scattered	good
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 14		Cow pea	none	weak
Humus	2,000 lbs.	Soy bean	1 nodule	"
Organic ash	25 "	Crim. clover	scattered, large	"
Sodium Carbonate	15 "	Alfalfa	"	medium
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 15		Cow pea	scattered	fair
Humus	2,000 lbs.	Soy bean	slight inoc.	weak
Organic ash	25 "	Crim. clover	good inoc., large	good
Sod. Carbonate	15 "	Alfalfa	scattered, large	"
Acid Phos.	50 "			
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 16		Cow peas	none	none
Humus	2,000 lbs.	Soy beans	scattered	weak
Floats	400 "	Crim. clover	none	none
Sod. Carbonate	15 "	Alfalfa	"	weak
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 17		Cow peas	none	weak
Humus	2,000 lbs.	Soy beans	splendid	medium
Floats	400 "	Crim. clover	none	none
Potas. Carbonate	15 "	Alfalfa	good inoc.	good
Carbohydrate	30 "			
Inoc. soil	25 "			

TABLE II—(Continued).

Study of Flora on media Nos. 22, 23, 25, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.

Notes on Bacterial flora

Plate C—(C—1/100,000 gram) after two days incubation—45 colonies. Plate C—Medium 46—after 4 days, 800 to 1000 colonies—very few Azotobacters, some *B. radicicola*. Mostly urea bacteria.

Plate C—after 2 days incubation—20 colonies. Plate C—medium 46—after four days, 700 to 900 colonies probably urea bacteria.

Plate C—after two days incubation—25 colonies. Plate C—medium 46—after 4 days incubation—250 colonies, many Azotobacters and *B. radicicola*.

Plate C—after 2 days incubation—30 colonies. Plate C—medium 46—after 4 days incubation—about 275 colonies, mostly Azotobacters and *B. radicicola*.

Plate C—after 2 days incubation—30 colonies. Plate C—medium 46—after 4 days incubation—200 colonies—some Azotobacters and *B. radicicola*.

Plate C—after two days incubation—75 colonies. Plate C—medium 46—after 4 days incubation, 150 colonies—many Azotobacters and *B. radicicola*.

TABLE II—(Continued).

1/11/16: Started following composts

No. 18	
Humus	2,000 lbs.
Floats	100 "
Sod. Carbonate	15 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 19	
Humus	2,000 lbs.
Organic ash	100 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 20	
Humus	2,000 lbs.
Organic ash	50 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 21	
Humus	2,000 lbs
Organic Ash	25 "
Carbohydrate	30 "
Inoc. soil	25 "
No. 22	
Humus	2,000 lbs.
Organic ash	50 "
Calcium Carbonate	50 "
Carbohydrate	30 "
Inoc. soil	25 "

1/14/16: Planted composts to cow peas, soy beans, alfalfa and crimson clover. 3/30/16: Pulled all plants to study nodules and growth.

	Nodules	*Growth*
Cow peas	scattered, small	fair
Soy beans	scattered, small	medium
Crim. clover	none	none
Alfalfa	good	weak
Cow peas	good	good
Soy beans	abundant, large	"
Crim. clover	plentiful, big	"
Alfalfa	scattered, big	"
Cow peas	abundant inoc.	very good
Soy beans	very strong	very good
Crim. clover	abundant, large	very good
Alfalfa	very strong	very good
Cow peas	some inoc.	good
Soy beans	medium inoc.	"
Crim. clover	medium inoc.	"
Alfalfa	good inoc.	"
Cow peas	none	none
Soy beans	abundant inoc.	strong
Crim. clover	abundant inoc.	very strong
Alfalfa	good	very strong

TABLE II—(Continued).

Study of Flora on media Nos. 22, 23, 25, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.

Notes on Bacterial flora

Plate C—after 2 days incubation—45 colonies. Plate C—medium 46—after 4 days incubation, 200 colonies—Azotobacter and *B. radicicola.*

Plate C—after 2 days incubation has 50 colonies. Plate C—medium 46—after 4 days incubation; 100 colonies, large proportion probably Azotobacters—some *B. radicicola.*

Plate C—after 2 days incubation has 20 colonies. Plate C—medium 46—after 4 days incubation—150 colonies—some *B. radicicola* and Azotobacters.

Plate C—after two days incubation—30 colonies. Plate C—medium 46—after four days incubation—200 colonies—many small Azotobacters and *B. radicicola* colonies.

Plate C—after two days incubation—50 colonies. Plate C—medium 46—after four days incubation, 250 colonies, some Azotobacters, and many *B. radicicola.*

TABLE II—(Continued).

1/11/16: Started following composts		1/14/16: Planted composts to cow peas, soy beans, alfalfa and crimson clover. 3/30/16: Pulled all plants to study nodules and growth.	
		Nodules	*Growth*
No. 23			
Humus	2,000 lbs.	Cow peas	few, small	medium
Guano	10 "	Soy beans	few, large	strong
Calcium Carbonate	50 "	Crim. clover	abundant, small	good
Carbohydrate	30 "	Alfalfa	few, small	"
Inoc. soil	25 "			
No. 24				
Humus	2,000 lbs.	Cow peas	small nod.	small
Guano	10 "	Soy beans	very few	"
Organic ash	50 "	Crim. clover	abundant, small	"
Carbohydrate	30 "	Alfalfa	none	none
Inoc. soil	25 "			
No. 25				
Humus	2,000 lbs.	Cow peas	abundant, very large	very healthy
Pot. Carbonate	10 "	Soy beans	good, large	very healthy
Acid Phos.	50 "	Crim. clover	medium, small	very healthy
Calcium carbonate	100 "	Alfalfa	abundant, very large	very healthy
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 26				
Humus	2,000 lbs.	Cow peas	few	medium
Potassium Carb.	10 "	Soy beans	abundant, large	healthy
Thomas slag	25 "	Crim. clover	plentiful small	"
Calcium carb.	100 "	Alfalfa	scattered, medium size	small
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 27				
Humus	2,000 lbs.	Cow peas	abundant, medium	large, healthy
Calcium carb.	100 "	Soy beans	abundant, large	very healthy
Carbohydrate	30 "	Crim clover	none	none
Inoc. soil	25 "	Alfalfa	scattered, medium size	small

TABLE II—(Continued).

Study of Flora on media Nos. 22, 23, 25, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.

Notes on Bacterial flora

Plate C—after two days incubation—450 probably nitrifying bacteria. Plate C—medium 46—after four days incubation, 100 colonies—many nitrifying bacteria.

Plate C—after two days incubation—900 colonies—probably nitrifying bacteria. Plate C—medium 46—after four days incubation, 500 colonies—probably nitrifying bacteria.

Plate C—after two days incubation—100 colonies. Plate C—medium No. 46—after 4 days incubation—200 colonies—some Azotobacters—few *B. radicicola.*

Plate C—after two days incubation—30 colonies. Plate C—medium No. 46—after four days incubation—200 colonies—many Azotobacters—many *B. radicicola.*

Plate C—after two days incubation—50 colonies. Plate C, medium 46—after four days incubation—150 colonies, some Azotobacters and *B. radicicola.*

22

TABLE II—(Continued)

1/11/16: Started following composts		1/14/16: Planted composts to cow peas, soy beans, alfalfa and crimson clover. 3/30/16: Pulled all plants to study nodules and growth.		
			Nodules	*Growth*
No. 28		Cow peas	abundant, large	very healthy
Humus	2,000 lbs.	Soy beans	abundant large	plants healthy
Organic ash	25 "	Crim. clover	exceedingly abundant	splendid
Thomas slag	25 "	Alfalfa	scattered but large	small
Cal. Carb.	100 "			
Carbohydrate	30 "			
Inoc. soil	25 "			
No. 29		Cow peas	none	healthy
Humus	2,000 lbs.	Soy beans	"	"
		Crim. clover	good inoc.	"
		Alfalfa	none	"
No. 30		Cow peas	abundant inoc.	healthy
Humus	2,000 lbs.	Soy beans	abundant inoc.	"
Carbohydrate	30 "	Crim. clover	abundant inoc.	"
Inoc. soil	25 "	Alfalfa	good inoc.	"

TABLE II—(Continued).

Study of Flora on media Nos. 22, 23, 25, 39, 43A, 43B, 44A, 44B, 45A, 45B, and 46.

Notes on Bacterial flora

Plate C—after two days incubation—60 colonies. Plate C—medium 46—after four days incubation—300 colonies, many Azotobacters, probably *A. chroococcum*, many *B. radicicola*.

Plate C—after two days incubation—5 colonies. Plate C—medium 46—after four days incubation—50 colonies, some Azotobacters, few *B. radicicola*.

Plate C—after two days incubation—50 colonies. Plate C, medium 46, after four days incubation—150 colonies, mostly Azotobacters and *B radicicola*.

The Flora in the Different Composts

Remarkable changes were brought about in the muck by the application of various ingredients. The different applications of wood ashes, sodium carbonate and potassium carbonate greatly increased the *Azotobacters*, especially the species *A. chroococcum*. (See the dark colonies in plate X).

The influence of basic materials in every compost was to reduce molds, but in some cases they increased *Actinomyces*. This observation is in harmony with studies that have been made on agricultural soils, especially those having large amounts of alkaline salts, such as potassium and sodium carbonates. One of the soils from Colorado, high in basic compounds, showed ten million *Actinomyces albus* per gram. This number is far in excess for this organism from soils which are neutral or acid.

The influence of the carbohydrate was to bring up immediately an abundant *Azotobacter* flora, the species varying with the amount and nature of the basic materials applied. As stated above, the basic materials containing alkaline compounds greatly favored *Azotobacter chroococcum*. The inhibiting action on moulds of a properly balanced compost is seen by comparing cultures A and B, Plate VIII, in which plate A is from a compost that has been properly balanced by alkaline bases. The influence of lime and other bases was very marked in the great increase of *B. radicicola*. In some cases the increase was a hundred to a thousand fold or more. The increase in *Azotobacters* was frequently a thousand fold. The rapid disappearance of moulds was remarkable. They evidently died out, as they failed to come up in the culture media when plating. The most remarkable influence of the bases was upon the nitrifiers, here these minute organisms which carry out such an important work, showed a wonderful increase. The importance of these biological processes and the part played by lime and the alkaline compounds must not be underestimated.

In the composts containing cyanamid and guano, especially the former, marked increases were noticeable in the urea bacteria. The most abundant flora was found in the composts containing cyanamid. Here, a plating from a dilution of 1/100,000 gram of moist compost was not sufficient to permit of proper development. Over 900 colonies of urea bacteria, probably *Bact. fluorescens* per 1/100,000 gram of moist compost were counted or rather estimated in a plate.

Symbiosis or Mutualism Probably an Active Factor with Azotobacters and B. radicicola

Thruout this work there is abundant evidence that there exists a strong mutualism between different species of *Azotobacter* and *B. radicicola*. It was observed that in all the media favorable for growth of *Azotobacter*, the same was very suitable for *B. radicicola;* in fact Ashby's medium proposed for Azotobacters, (Jour. of Agr. Science II.—1907-8—p. 54), was equally a splendid medium for *B. radicicola*. It was observed that wherever a colony of *B. radicicola* started on a plate, that when *A. chroococcum* or other azotobacters became a part of the colony the rapidity of growth for both was very marked. When *Azotobacters* are carried in tube cultures they live and make splendid growth when they are associated with *B. radicicola*. The *B. radicicola* shows an equal benefit from the mutualism. It is believed that in the older root tubercles of legumes, *B. radicicola* is rapidly followed up by certain *Azotobacters*. This appears certain from the many *Azotobacters* which have found their way into old but apparently sound nodules, as indicated by surface sterilizing and plating. Many years of study of *B. radicicola* on pure culture and its rapid deterioration and failure, and on the other hand great success when carried in soil has led to the conclusion that symbiosis or rather mutualism is a great factor in preserving and benefitting a soil flora.

It has been inferred by certain producers of commercial inoculants that the organism of each particular legume requires a culture medium slightly different from that of another, and particularly adapted for the organism in question; further that "the germs for one variety of legumes will not work on any other variety of legume." In the light of recent investigations, the present work shows that the organisms for the different groups of the important agricultural legumes may be successfully carried in one and the same compost.

The Influence of Various Compounds on Inoculation

The influence of the composition of the compost is apparently not so active on the soil flora as it is on the host. This was especially to be noted on the growth of the different legumes. In many instances when the roots of the legumes failed to penetrate deeply into the compost because of excessive acidity or alkalinity, the few roots which were to be found showed an abundant inoculation. On the other hand, in certain composts where the nitrogen available was too

great, altho the legumes showed splendid growth and a bountiful root system, little or no inoculation was to be found. It required strong acidity and alkalinity in the compost before a marked falling off in the *B. radicicola* content could be detected in cultures. On the other hand, a slight excess of sodium and potassium carbonates, either from that applied in organic ash or when applied in the form of chemically pure goods, would show detrimental effect on soy beans and cow peas. However, red clover and most especially alfalfa were quite tolerant to alkali. Alfalfa was in every case the last to die out from excessive alkalinity. The influence of an excess of these carbonates was to be seen on the growth of soy bean and cow pea in composts numbers 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6B, 14, 15, 16, 18 and 19. Because of the detrimental effect of these alkalies on soy beans and cow peas in some of these composts no inoculation apparently took place. (See Table II, composts 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 5B 6A and 6B) Some of these same composts gave splendid inoculation on clover and alfalfa (See Table II, composts 4A-5A). The size and apparent health of the nodule was very noticeable on clover and alfalfa grown in some of these sodium and potassium carbonate treated pots. The influence of fertilizers carrying nitrogen, such as cyanamid and guano, was to inhibit or weaken inoculation. This was plainly seen in composts 12, 13, 23, and 24, the two former carrying cyanamid nitrogen, and the two latter, nitrogen from a high grade guano.

Statements have been made that the nodule organisms do not live well in an acid soil. In pot C and Pot No. 30, we have added inoculation but no bases; the results were a very good inoculation on all the legumes, soy beans, cow peas, clover and alfalfa and this in a humus that shows a lime requirement of nearly 5,000 pounds of CaO per 2,000,000 pound acre. (See plate IV showing photograph of inoculation in pot 30). The growths of the legumes on pots C and 30 were also fairly good, showing that these plants were able to tolerate an acidity in the form of humus, that was nearly three times that of the average acid soil.

The best inoculations were found in those composts which were well balanced in their make-up, such as composts Nos. 8, 25 and 28. Here there is not only an abundant and well distributed inoculation, but also plant growth which shows health and vigor. See plates V and VI for the inoculation in No. 25 and No. 28 and plate II for growth of legumes on these composts.

Inoculation in Sterilized Sand By Use of Composts

This work was carried out in 7-inch plant pots, sterilizing the sand in the autoclave four hours, at a pressure of fifteen pounds. The composts were used at the rates of 3 pounds, 100 pounds and 500 pounds respectively to a 2,000,000 pound sand acre. (This would be equivalent to about a six inch acre). Five different legumes were employed, representing as many different nodule organism groups, viz., alfalfa, clover, vetch, cow peas and soy beans. This work was done in duplicate. The sand was treated with ground limestone and washings from wood ashes to supply the necessary minerals. The work was duplicated, using two different composts for inoculation. The appearance of the legumes was somewhat better where 100 pounds and 500 pounds respectively of the composts were used, but upon examination, it was found that good inoculation had taken place in all the pots, and among all the legumes. (See Plate VII.) This work readily indicates that the organisms for each and all of the important groups of agricultural legumes may be carried in one compost. An observation which was of particular interest in this work was the immense amount of root growth in the sand cultures as compared with the top growth on the legumes. The same relationship must take place in the growth of legumes on weak sandy soils. The following shows dry weights in grams, of tops and roots from the series inoculated with 100 pounds of compost per acre.

Dry Weights of Tops and Roots of Legumes Grown in Sand Cultures.

	Wt. of Tops	Wt. of Roots
Alfalfa	5.1 grams	12 grams
Clover	4. "	12 "
Vetch	4.5 "	11 "
Cow Peas	7.2 "	10 "
Soy Beans	6. "	9 "

The splendid inoculation produced in these sand cultures would indicate that such humus as was used in these experiments, could readily be inoculated and composted so as to carry all the important organisms for the inoculation of the different groups of important agricultural legumes.

The Influence of the Basic Compounds on the Availability of Humus Nitrogen

The importance of basic compounds in making available the nitrogen of humus has long been known. Certain of the elements, such as calcium, magnesium, iron, manganese and aluminum form insoluble humates in the soils, while others such as sodium and potassium, especially the carbonates of these and the compound ammonia, have the property of making humates soluble. Humus or probably more properly speaking, humic acid has stronger affinity for sodium, potassium, iron, aluminum, and phosphorus than it has for calcium and magnesium. This is very evident when the Grandeau method for humus is applied, in which the calcium and magnesium are almost entirely taken out by the preliminary treatment with weak hydrochloric acid, while the other basic materials are not separated from the humus. This fact is plainly seen when the ash content of humus as reported by Snyder[1] (Hilgard, "Soils," p. 134, 1906), and given herewith for reference is observed.

Ash of Humus from Minnesota Prairie Soils

Insoluble matter	61.97
Potash (K_2O)	7.50
Soda (Na_2O)	8.13
Lime (CaO)	0.09
Magnesia (MgO)	0.36
Peroxide of Iron (Fe_2O_3)	3.12
Alumina (Al_2O_3)	3.48
Phosphoric Acid (P_2O_5)	12.37
Sulfuric Acid (SO_3)	.98
Carbonic Acid (CO_2)	1.64

The cultural tests with rye and millet were used only as indicators to show whether small or large amounts of the humus nitrogen were being made available for the plants. The following table shows the crop response from rye both green and dry, which was harvested from the different composts after a growing period of eight weeks. (See Plates XI, XII and XIII).

29

TABLE III

Showing Green and Dry Weights of Rye Grown Eight Weeks

Compost No.	Green Weight in Grams	Dry Weight in Grams
A check	63	11
B	88	16.5
C	56	11
D	117	25
1A	252	45
1B	312	45
2A	187	34.5
2B	257	38.5
3A	167	34
3B	78	10.5
4A	95	21.0
4B	220	40
5A	141	31
5B	169	32
6A	160	34
6B	130	23
7A	125	26.5
7B	125	24
8A	Pot removed before data were taken.	
8B	173	33.5
9	342	66
10	313	60.5
11	0	0
12	303	47
13	57	18
14	115	19
15	107	25.5
16	127	23
17	89	21
18	146	29
19	210	40
20	149	32
21	146	30
22	152	31
23	383	54
24	281	49

30

TABLE III—(Continued).

Compost No.	Green Weight in Grams	Dry Weight in Grams
25	Pot removed before data were taken.	
26	139	28
27	73	14.5
28	100	22.5
29 check	50	11.5
30 check	75	16.5

From Table III, it is very apparent that the addition of certain basis materials has strong influence on the nitrogen assimilation. Check composts A and No. 29 show the response from humus not reinforced or inoculated with soil organisms; these gave a response to rye of 11 and 11.5 grams of dry material (See Plates XI and XIII.)

Check C shows that inoculation alone did not help any, giving a dry weight of only 11 grams; however, when a stimulant or bacterial food such as a crude carbohydrate is added, the pot, without inoculation, is increased by 5.5 grams or 50%, as seen in Check B. When such crude carbohydrate and inoculation are added, the increase is 14 grams or about 122%. Composts numbers 1A, 1B, 2A and 2B show the importance of organic ash, both with and without addition of acid phosphate. The two former have additions of acid phosphate, and show nearly 50% increase above the two latter, which have no additional phosphorus. The difference between Check D, and composts 2A and 2B respectively, shows the influence of organic ash, which is an increase of 9.5 grams and 13.5 grams, or when placed on a per cent basis, is 34% and 54%; the latter shows that when it comes to rye response that 200 pounds of organic ash per ton of humus is superior to 100 pounds. However, 50 pounds of acid phosphate, when added to the 200 pounds of organic ash per ton of compost, show a further increase, viz., the difference between 45 grams and 38.5 grams, or 6.5 grams, which is an increase of nearly 17%.

The detrimental effects of an excess of sodium or potassium carbonates are to be observed in various composts from 3A to 6B nd 14 to 18 respectively, in which certain pots made very poor growth, especially 3B, in which 100 pounds of potassium carbonate and 50 pounds of commercial 16% acid phosphate were used. Here, the dry weight was only 10.5 grams, which was 14.5 grams less than check D. Detrimental effects with 15 pounds or more sodium and potassium carbonates were observed unless the compost was properly balanced

with acid phosphate. Attempts to supplement applications of ashes with sodium or potassium carbonate resulted in decreased yields of rye, as seen by comparing compost No. 19, containing ashes which gave a dry weight of 40 grams, with composts Nos. 14 to 18 respectively, in which ashes were reinforced with sodium or potassium carbonates; here, the weights were 19, 25.5, 23, 21 and 29 grams respectively.

Calcium carbonate does not equal the response of wood ashes; this is seen by comparing compost No. 19, containing 100 pounds of ashes per ton of humus and producing a dry weight of rye of 40 grams, with compost No. 27 containing an equal amount of calcium carbonate per ton of humus, which gave a rye response of only 14.5 grams.

It is very difficult to make a comparison in humus pot cultures of the value of humus nitrogen with that of cyanamid and guano nitrogen; from the fact that the humus must be properly balanced before proper crop response can be expected. Such comparisons were attempted with cyanamid in pots Nos. 9, 10, 11, 12 and 13, in which pots No. 9 and No. 12 were supposedly well balanced composts. However, 10 pounds of cyanamid in a ton of humus, with no acid phosphate added, gave a higher rye response than did 10 pounds of cyanamid and fifty pounds of acid phosphate. It may be that where the acid phosphate was added, an inhibiting effect from this combination took place, although such was not the case when acid phosphate was used with ashes. The dry weights were respectively 66 grams and 47 grams. When cyanamid at the rate of 25 pounds per ton of humus was added, the crop response on rye was 60.5 grams dry weight as compared with 47 grams when 10 pounds of cyanamid and 50 pounds of acid phosphate were added. Ten pounds of cyanamid alone gave a higher rye response (66 grams dry weight) than did ten pounds of guano when the humus and the latter were balanced with 50 pounds of calcium carbonate or 50 pounds of ashes. (Compare pot 9 with pots 23 and 24).

The highest responses given to rye by the best humus composts to which no nitrogen was added, were found in composts 1A, 1B and No. 19, in which the dry weights were respectively 45, 45 and 40 grams. This is an increase over the untreated or uncomposted humus, using check A (11 grams dry weight) of 34, 34, and 29 grams respectively; in the two former the increases are over 300 per cent. Comparing this with the responses from the properly composted guano, which gave an increase over check A of 38 and 43 grams respectively, the response

from the humus nitrogen is a close competitor. The chief object, however, of adding cyanamid and guano nitrogen was not to obtain a comparison of crop response from these different sources of nitrogen, but to learn whether greater crop response could be brought about by such addition, and further whether cyanamid and guano were suitable sources for such reinforcement. Rye, in some cases, as noted above, gave slight additional increase from reinforcement with cyanamid and guano, while millet on the other hand gave greater response from twelve different composts, not reinforced with nitrogen, than from those pots receiving additional nitrogen from cyanamid and guano. The response from the cyanamid nitrogen in pot 9, viz., 66 grams dry weight, compares favorably with that from guano nitrogen in pot 23, which gave 54 grams dry weight. Here equal weights are being used; that is, 10 pounds of each in a ton, and the former is listed to contain nearly twice the amount of nitrogen as the latter. The guano was represented to be "genuine Peruvian Guano" having the following analysis:

Nitrogen	10.69%
Equivalent to Ammonia	13.00%
Available Phosphoric Acid	10.00%
Total Phosphoric Acid	11.00%
Actual Potash	3.00%

Crop Response from Millet

A study of the crop response from millet shows even more favorable results from the composts. None of the pots reinforced with cyanamid nitrogen or guano equalled the composts Nos. 1A, 1B, 7B and 22. In fact there were 12 different composts which gave higher crop production than did those reinforced with cyanamid and guano.

With the exception of compost No. 22, compost 1B was again the most productive, being closely followed by No. 7B and No. 1A. The dry weight with millet from these leading pots was over five times that from check A, while with rye it was only four times that of the check. No attempt will be made to interpret the response from the different composts. It is sufficient to indicate the compounds which appear to be very active in bringing about such response. Carbohydrates, apparently have great influence as there is a difference between raw humus in check A and that of humus and the crude carbohydrate in check B of 38 grams which is a response of nearly 176%. The addition of ashes to check D, as seen in pot 2A, gives 94 grams dry weight

or an increase from 65 to 94 grams, that is 29 grams, which is equal to 44.6% increase.

If compost 1B is compared with check A, it is evident that the addition of acid phosphate, ashes, the crude carbohydrate and inoculation changes the response from 22 grams, dry weight, to 116 grams or an increase of 472.7%.

Inoculation as shown in crop response in rye and millet has been the weakest factor at work, the increase from check A to check C amounting to three grams, that is the difference between 22 and 25 grams; this is an increase of only 13.6%. The increase produced by inoculation in the presence of a crude carbohydrate as seen in the increase from check B to check D is only 8.3%. Ashes and ground limestone more than doubled the crop as seen by comparing check 30 with pot 22 in which the former produced 55 grams and the latter 121 grams. The detrimental influence of an excess of potassium carbonate is seen in compost 3B, in which 100 pounds were added per ton of humus. In compost 6B, 60 pounds of sodium carbonate show a decidedly injurious effect. Table IV shows the green and dry weights of millet produced in eight weeks of growth on the different composts.

TABLE IV

Showing Green and Dry Weights of Millet Grown Eight Weeks

Compost No.	Green Weight in Grams	Dry Weight in Grams
A Check	105	22
B "	282	60
C "	125	25
D "	297.5	65
1A	377	113
1B	387.5	116
2A	352.5	94
2B	415	97
3A	310	75
3B	97.5	20
4A	192.5	34
4B	382	96.5
5A	387.5	106
5B	410	109
6A	253	63
6B	57.5	11
7A	248	52

TABLE IV—(Continued).

Compost No.	Green Weight in Grams	Dry Weight in Grams
7B	397	114
8A	Pot Removed	Pot Removed
8B	310	65
9	175.5	42
10	139	35
11	0	0
12	177	36
13	262.5	60
14	340	90
15	382.5	108
16	270	54
17	357.5	69
18	240	58
19	328	92
20	355	86
21	302.5	63
22	352	121
23	100	19
24	382	76
25	Pot removed	Pot Removed
26	340	75
27	165	29
28	355.5	85
29	114	22
30	257.5	55

Crop Response in Relation to Nitrification and Water Soluble Humus

It was thought that probably some light would be thrown upon the crop response by a study of nitrification. Accordingly, after harvesting the rye, the composts were carefully worked over, that is thoroughly mixed and moistened down; they were then kept at optimum conditions for two weeks when samples were removed for a study of nitrification. Twenty gram samples of the air dried composts were moistened with 150 cc of distilled water. After shaking for fifteen minutes, 100 cc of the water extract was filtered off and evaporated for nitrate determination. In some instances the color of the water extract was a very dark brown, showing that the treatment with the alkali carbonates was making the humus soluble. The following table

shows the color of the water extract, the reaction to litmus paper, and the amount of nitrate present in 20 grams of the air dry compost.

TABLE V

Showing Color of Water Extract, Reaction to Litmus Paper, and Amount of Nitrates found in each Compost

Number of Compost	Color of Water Extract	Reaction to Litmus	Milligrams of Nitrate Nitrogen in 20 grams of compost
A	light straw	acid	.0100
B	light straw	acid	.0200
C	light straw	acid	.0500
D	light straw	acid	.0150
1A	almost clear	alkaline	.0400
1B	darker than A	alkaline	.0300
2A	quite yellow	alkaline	0350
2B	strong cider yellow	alkaline	.0950
3A	yellowish brown	alkaline	.0350
3B	very dark brown	alkaline	2.5000
4A	lighter than A	almost neutral	.0100
4B	darker than A	alkaline	.0200
5A	darker than A	alkaline	.0150
5B	quite yellow	alkaline	.0400
6A	stronger than 5B	alkaline	.0250
6B	very dark brown	alkaline	.6000
7A	same as A	alkaline	.0200
7B	same as A	alkaline	.0250
8A	compost removed before	data were taken	
8B	same as A	alkaline	.0250
9	clearer than A	alkaline	3.6875
10	very clear	alkaline	10.6500
11	darker than A	alkaline	.0800
12	clearer than A	acid	5.6250
13	clearer than A	acid	8.5250
14	Red cherry brown	alkaline	.0650
15	same as A	alkaline	.0100
16	very dark brown	alkaline	.0350
17	cider brown	alkaline	.0200
18	dark brown	alkaline	.0250
19	quite yellow	alkaline	.0150
20	same as A	alkaline	.0100
21	lighter than A	alkaline	.0200
22	same as A	alkaline	.0150
23	lighter than A	alkaline	.0050

TABLE V—(Continued).

Number of Compost	Color of Water Extract	Reaction to Litmus	Milligrams of Nitrate Nitrogen in 20 grams of compost
24	little darker than A	alkaline	.1050
25	compost removed before	data were taken	
26	little darker than A	alkaline	.0100
27	same as A	alkaline	.0250
28	same as A	alkaline	.0100
29	same as A	acid	.0300
30	little darker than A	acid	.0250

From a study of Table V it is readily noticeable that composts showing almost no nitrate nitrogen gave splendid crop response with both rye and millet. It is difficult to know just how to interpret this. It is quite probable that other forms of nitrogen, than nitrate, cause ready crop response; and it may be possible that this form of nitrogen is not even the ammoniacal form.

The small amount of nitrate nitrogen in compost No. 11 would indicate that 200 lbs. of cyanamid per ton of humus is sufficient to stop entirely nitrification. On the other hand 25 lbs. of cyanamid per ton of humus shows strong nitrification. The composts containing guano showed less nitrate nitrogen than the check pots. It is hard to interpret this fact unless a denitrifying flora is at work.

Some Modifications of Media Used in This Work

For general plating of *B. radicicola* and *Azotobacters*, Ashby's medium has been used. (Jour. Agr. Sci. Vol. II, p. 54 1907-'08). It is prepared as follows:

Mannit	10.0 grams
Mono-potassium phosphate	0.2 "
Magnesium sulphate	0.2 "
Sodium chloride	0.2 "
Calcium sulphate	0.1 "
Calcium carbonate	5.0 "
Agar	12.0 "
Pure water	1000.0 cc

To favor a better growth of *Azotobacter, Nitrosococcus* and *Nitrobacter*, the following soil extract has been substituted in place of the water above. Take 500 grams of rich garden soil and add 2,000 cc of

water to which one gram each of ammonia tartrate and sodium citrate have been added. After vigorously shaking, the soil is allowed to settle; upon standing 24 hours the clear supernatant liquid is siphoned off. 1,000 cc of this soil extract is substituted for the water in Ashby's medium. (This medium is the senior author's medium No. 46).

To favor the nitrifiers (*Nitrosococcus* and *Nitrobacter*) one gram of ammonium sulphate per liter of medium was added to Ashby's medium with the above soil extract.

The following medium known as the author's medium No. 39 is of especial value in bringing out nitrifiers so they may be seen as brown colonies on the plates. In plating soils on this medium, large plates of 110 mm or larger in diameter and only 10 cc of medium are used, so that a thin layer of medium is formed. One-ten thousandth or one-one hundred thousandth gram of soil is used for each plate.

Mono-potassium phosphate	(KH_2PO_4)	4.0 Grams
Ferric sulphate		0.2 "
Wood ashes (hard)		12.0 "
Mannit		10.0 "
Agar		15.0 "
Soil Extract (Manns', as noted above)		1000.0 cc

After tubing above (10 cc to a tube) add to each tube one gram of the following insoluble mixture, the ingredients of which have been passed thru a sieve of 120 mesh to the inch.

Calcium limestone (ground rock)	100 grams
Kaolin	20 "
Gypsum	10 "
Dolomite	5 "
Rock phosphate (floats)	5 "

After liquifying the medium and just prior to plating, add to each tube 1 cc of a sterile ammonium sulphate solution made as follows,—one gram of ammonium sulphate in 100 cc of water. The object of adding the sterile ammonium sulphate just prior to plating is to prevent loss of ammonia which would take place if the ammonium sulphate was added with the other ingredients which are basic.

When adding the soil dilution in the process of plating, thoroly shake just before pouring so that the above insoluble minerals will be

545

evenly distributed thruout the plate. It will form a gray mass or back ground on which the brown nitrifiers are very visible. For class work a qualitative test may be made around each nitrifying colony showing the plentiful formation of nitrates by a heavy blue coloration with the use of diphenylamine. This medium has been successfully used for several years by the senior author in class work.

Summary

1. Muck humus of the quality used in these experiments becomes, when properly balanced and reinforced, a very favorable medium for carrying a beneficial soil flora.

2. The flora of virgin muck humus was found low in many of the beneficial bacteria. Different legume nodule organisms were absent, though the clover group was present to a limited amount. The alfalfa, vetch-pea, bean, cow pea and soy bean groups were absent (see plate III).

3. Muck humus when properly reinforced, inoculated and composted will carry the several groups of the different legume organisms in one and the same compost, producing a strong inoculation on the different legumes.

4. Inoculation of the compost may be satisfactorily brought about by using soil which has been proved to give strong inoculation to each of the groups of legumes. *Azotobacter chroococcum* may be readily introduced by using western soil; soils from Colorado and North Dakota were used in these experiments. Other species of *Azotobacter* are common in eastern soils. Nitrifiers are common in all good soils.

5. Muck humus properly reinforced, inoculated and composted gave strong inoculation to five groups of legumes, when the latter were grown in sterilized sand cultures, using the compost at the rate of two pounds per a 2,000,000 pound acre. A somewhat stronger inoculation and growth were produced by using the compost at the rate of 100 and 500 pounds respectively to a two million pound acre in sand cultures (see plate VII).

6. Crude carbohydrates and basic compounds such as organic ash and Thomas slag proved very efficient in bringing up an active legume flora, and likewise a strong nitrogen fixing and nitrifying flora.

7. Organic ash proved the most active mineral application for use in the compost as indicated by crop response.

8. By properly reinforcing the composts with certain basic compounds, all the nitrogen required for crop response was made available as indicated by the growth of millet; the crop response from additional nitrogen from cyanamid and guano did not equal that from certain of the composts.

9. This work shows that the nodule organism may live well in a muck humus having a lime requirement of 5,000 pounds of CaO to a two million pound acre; also that in this same acidity four different legumes, viz. alfalfa, red clover, soy bean and cow pea, made good growth and took good inoculation without addition of any bases (see plate IV).

10. Muck humus as herewith reinforced and composted gave splendid crop response to rye and millet without the addition of nitrogen, indicating it to be a product of good fertilizing value.

Descriptions of Illustrations

Plate I—Showing four different legumes, viz., alfalfa, clover, cow pea, and soy beans, growing in the different composts to test same for inoculation.

Plate II—Same as plate I, showing four different legumes, viz., alfalfa, clover, cow pea, and soy beans growing in the different composts to test same for inoculation.

Plate III—Showing the amount of inoculation carried in the natural humus as dug from the trucking fields. The legumes were one month old when removed for photographing; (1) soy bean, (2) alfalfa, (3) crimson clover, (4) cow pea. The clover group is the only form of *B. radicicola* present.

Plate IV—Showing amount of inoculation taking place in one month's growth on soy bean, alfalfa, clover and cowpea, in natural humus to which inoculation but no minerals or bases have been added. A stimulant in the way of a crude molasses has been added. The inoculation is nearly equal to that shown in plates V and VI, to which bases have been added. Compare plate IV with plate III.

Plate V—Showing the amount of inoculation in compost No 25, in which bases have been employed. The soy beans, alfalfa, clover and

cow peas have taken a strong inoculation in one month. Compare with plate III.

Plate VI—Showing the amount of inoculation in compost No. 28 in which bases have been employed—all the legumes have taken a strong inoculation in one month.

Plate VII—Showing growth of five legumes, in sand culture, viz., alfalfa, crimson clover, vetch, cow peas and soy beans, representing as many different groups of *B. radicicola*. The amount of compost used was 2 lbs., 100 lbs. and 500 lbs. respectively. All showed strong inoculation indicating that in one compost all the groups may be successfully carried.

Plate VIII—Showing type of flora in natural humus (A) before composting and after composting (B). The molds and Actinomyces disappear and *Azotobacters*, *B. radicicola*, and nitrifiers become abundant. Culture A is from 1/10,000 gram of muck, and culture B is from 1/100,000 gram of muck.

Plate IX—Showing the bacterial flora from one-one hundred thousandths of a gram of soil, grown on Ashby's medium, comparing composts No. 20, 21, 22, 23 and 24, with the natural humus No. 29. A large increase in *Azotobacters* and *B. radicicola* has taken place.

Plate X—Showing the bacterial flora from one one-hundred thousandths of a gram of soil, grown on the author's medium, No. 46, adapted for *Azotobacters*. Here *Az. chroococcum* is shown plentiful in composts No. 1, 1-B, 6 and 6-B.

Plate XI—Showing growths of rye on the different composts. The influence of the bases is readily seen in composts 1-A and 1-B.

Plate XII—Continuation of work shown in plate XI—rye growing in different composts.

Plate XIII—Continuation of work shown in plates XI and XII —Rye growing in different composts.

Plate XIV—Showing color of water extract from different composts. Some were very dark brown. See Table V.

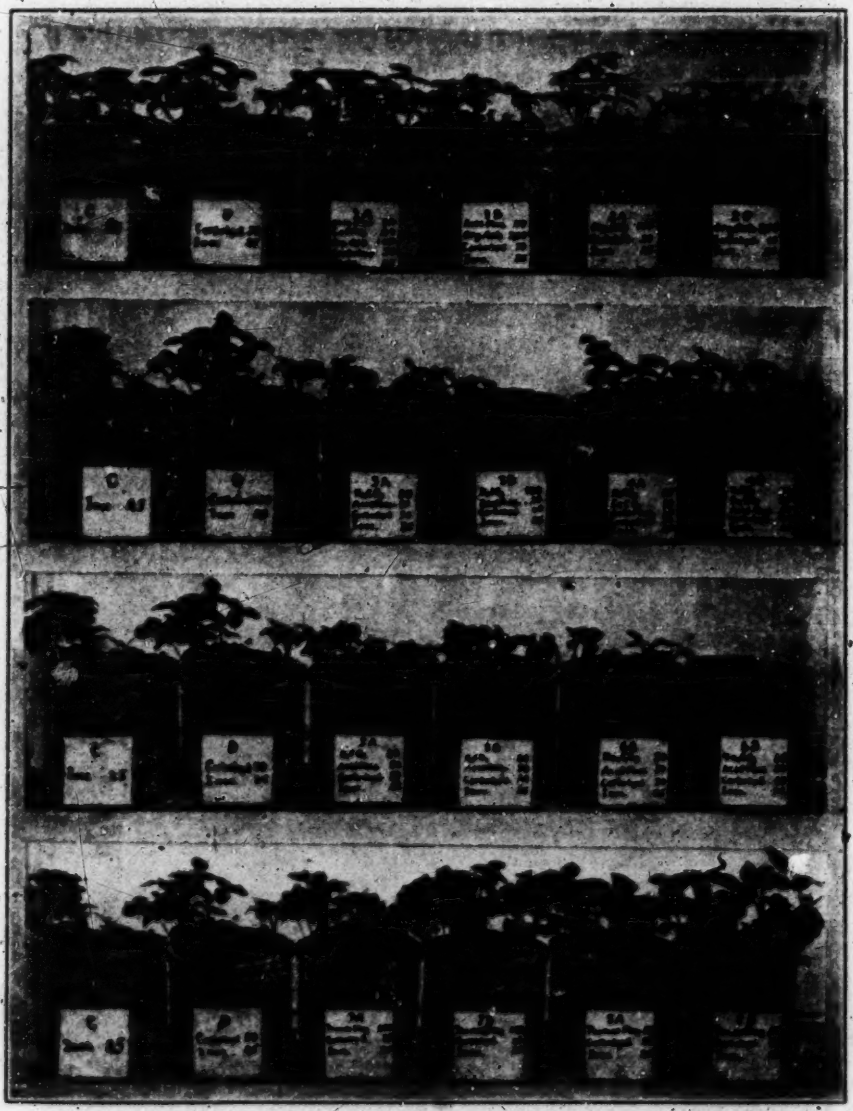


PLATE I.

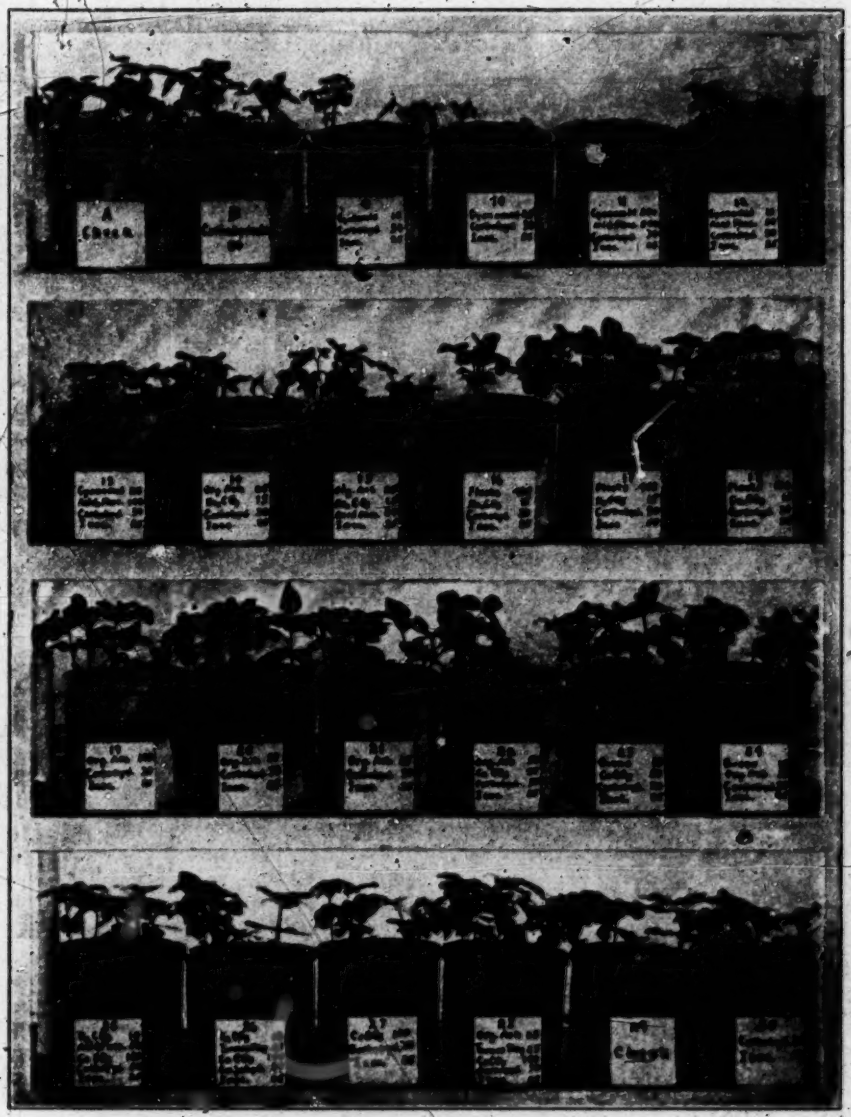


PLATE II

PLATE III

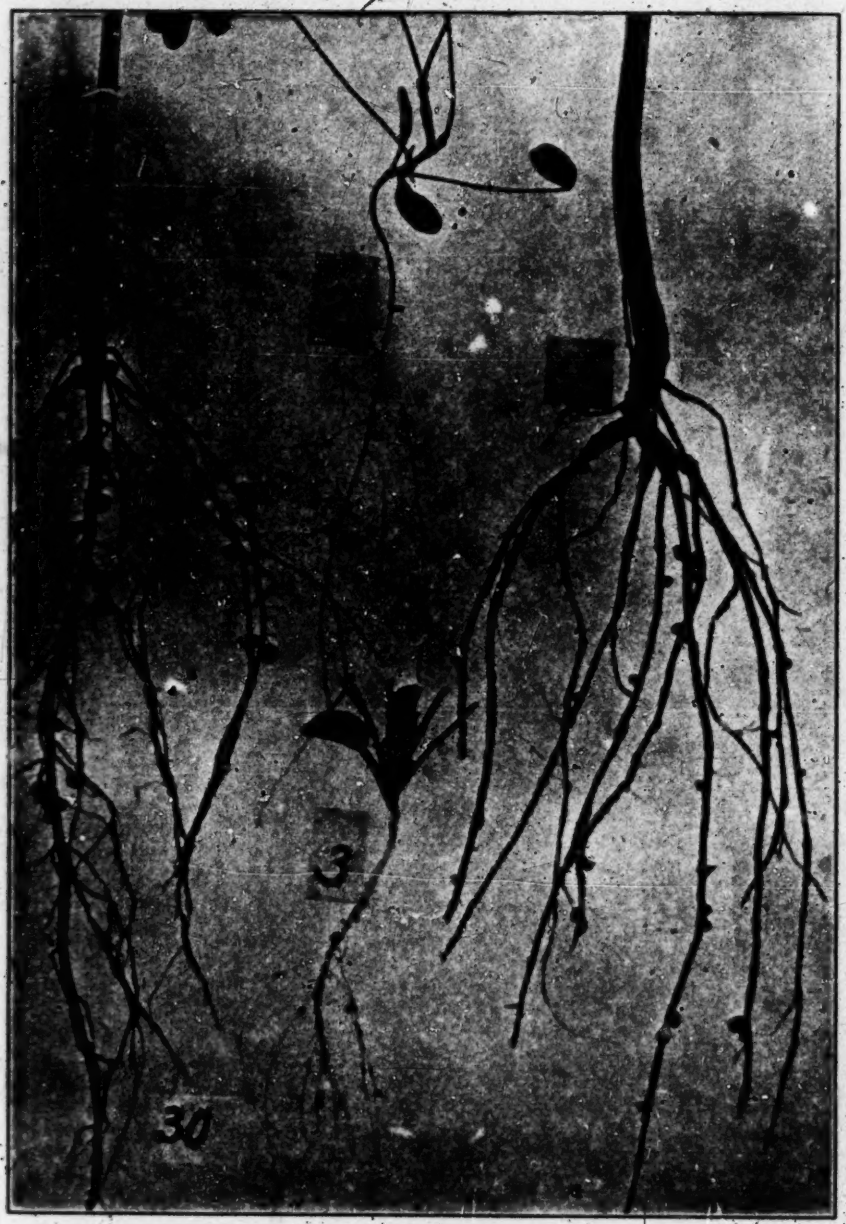


PLATE IV

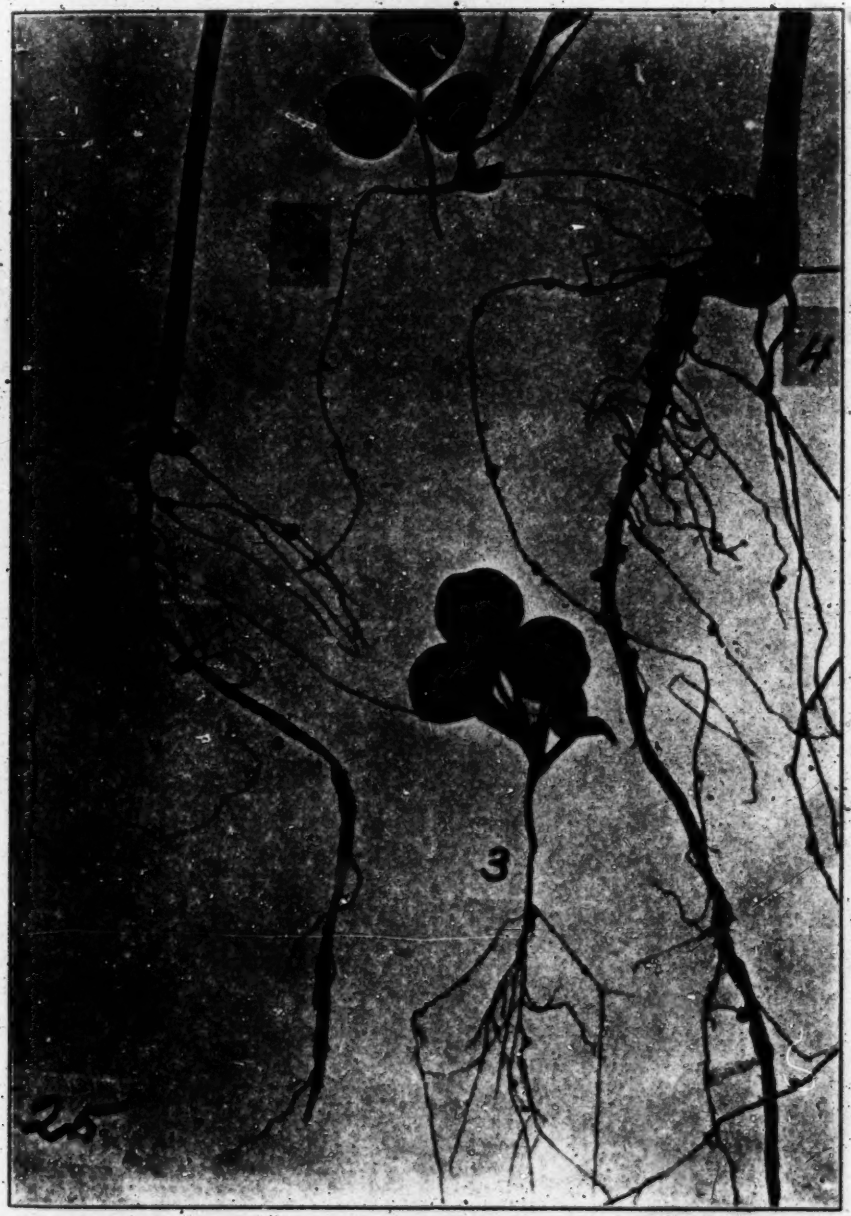


PLATE V

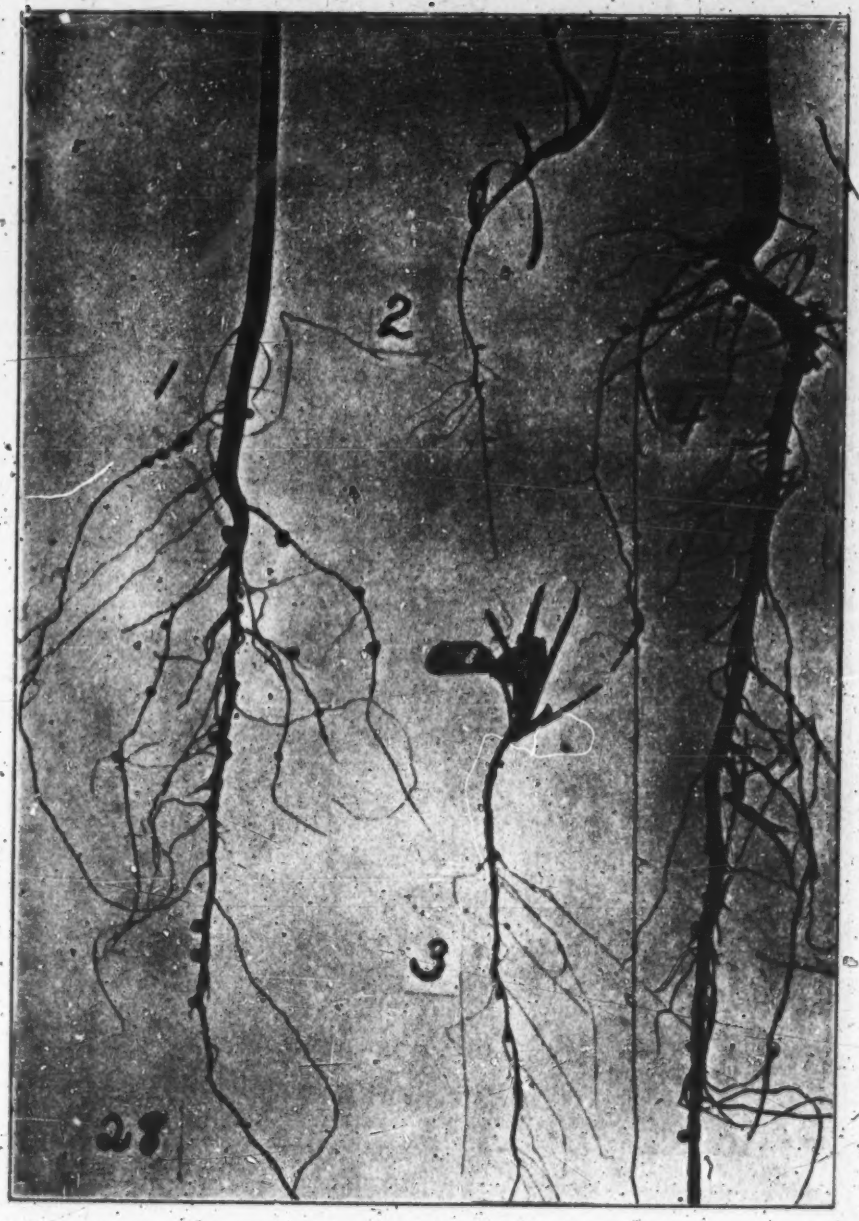
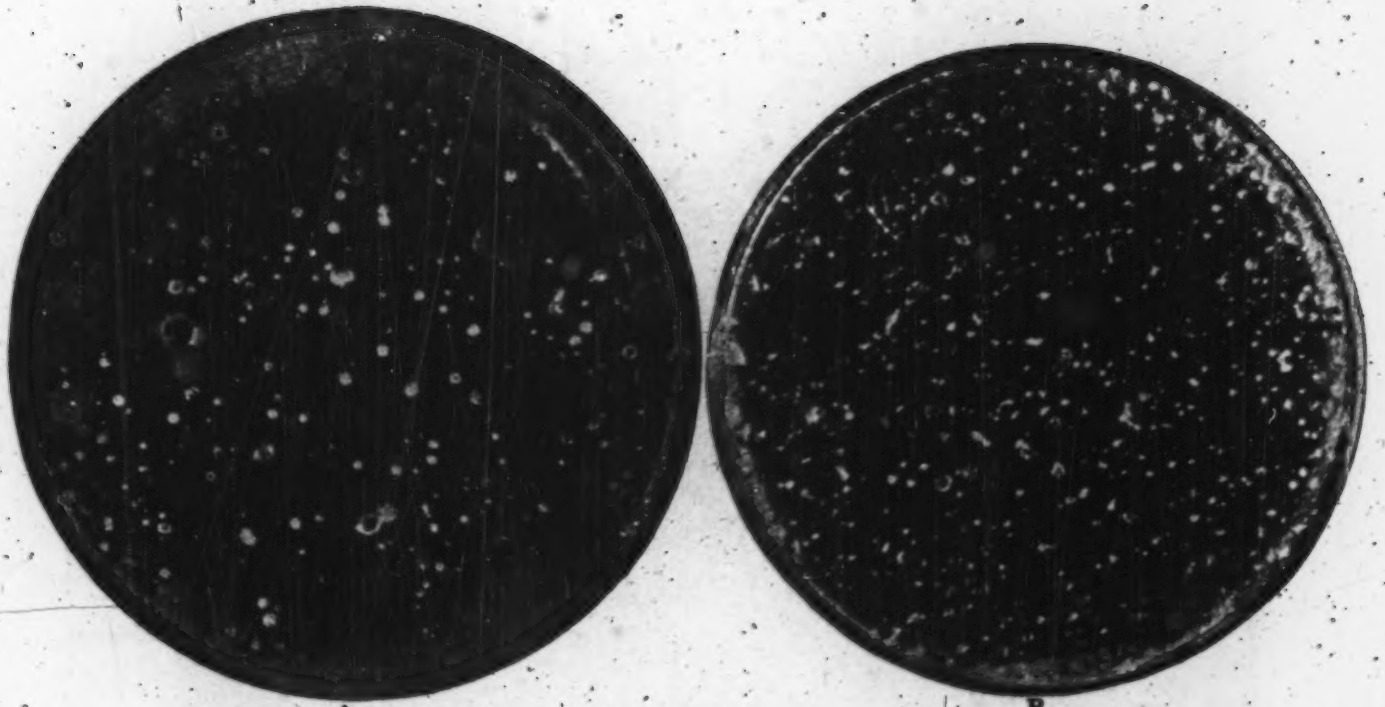


PLATE VI

PLATE VII



A B

PLATE VIII

PLATE IX

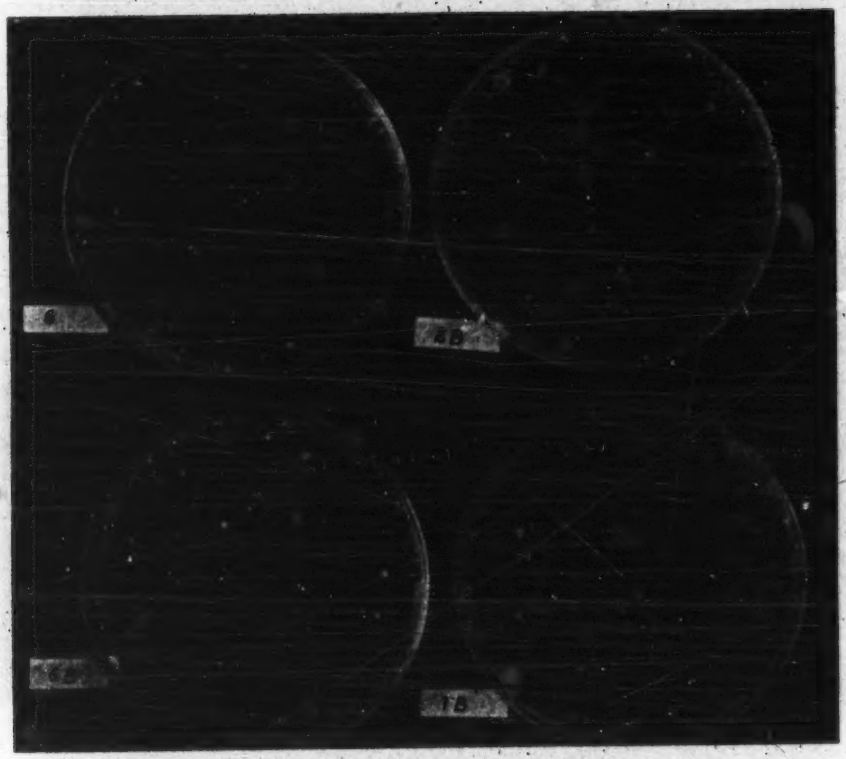


PLATE X

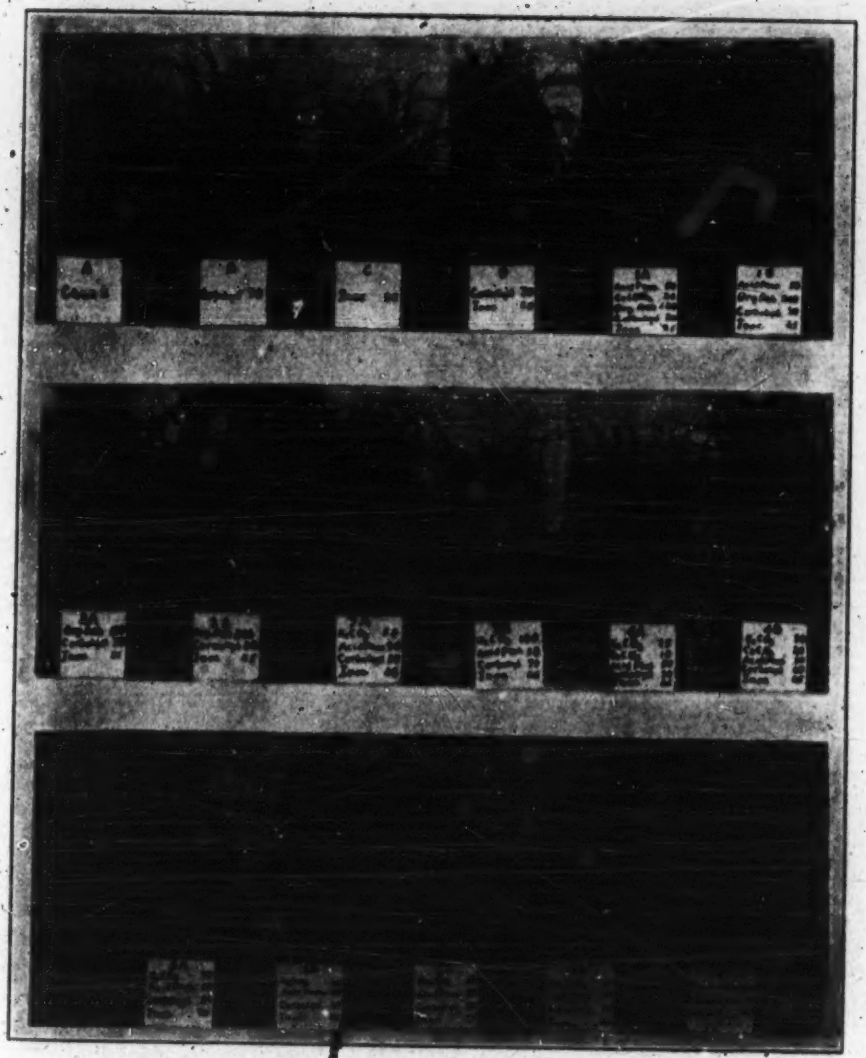


PLATE XI

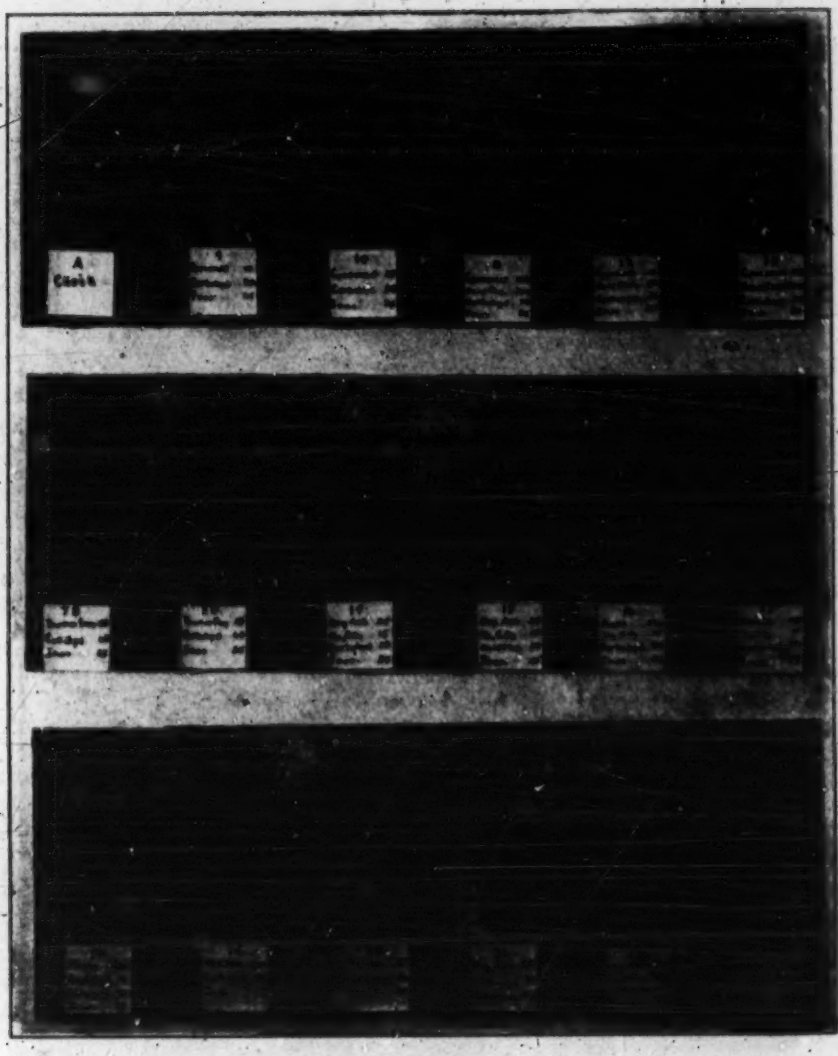


PLATE XII

PLATE XIII

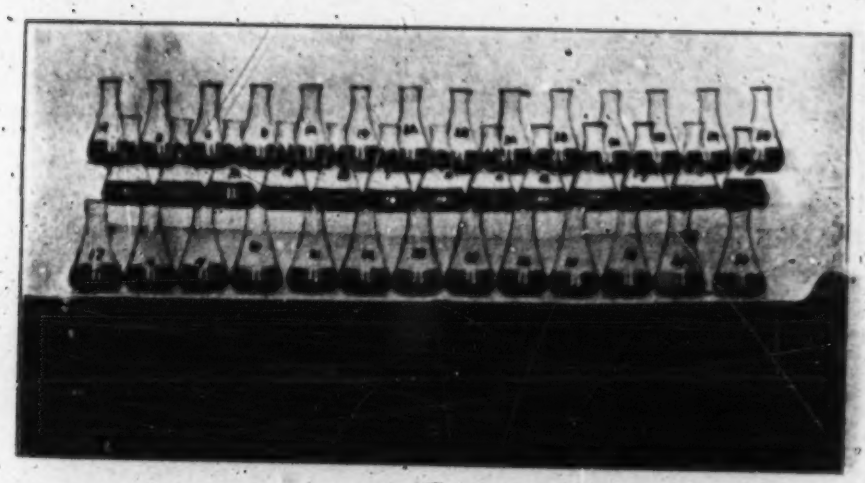


PLATE XIV

The Alphano Book

DEFTS. EX. 17 IDEN.

The Alphano Book

It has mainly to do with your soil and the best way to secure its highest fertility. With which are included some friendly hints on lawns, their care and fare; along with suggestions for your vegetables, flowers, shrubs and trees.

10 years on the market
Half a million tons sold.

Alphano Humus Co

Established 1905

Whitehall Building, 17 Battery Place
New York City

Subject Short Cut Guide

Page 3.

Soil Needs—A Short Talk on Them.

Page 4.

Natural Humus—An Explanation and a Caution.

Page 5.

Alphano—Its Strong Points.

Page 6.

For Lawns, Tennis Courts and Golf Links. What Alphano Will Do for Them.

Page 7.

Directions for Making New Lawns—Remaking Old Ones.

Pages 8-9.

Four Interesting Examples of Alphano Results with Flowers and Grass.

Page 10.

How to Use Alphano in both Your Flower and Vegetable Gardens.

Page 11.

Something About Peas, Beans, Celery and Some Interesting Points About Setting Out and Boosting Plants.

Page 12.

Two Letters Telling Phenomenal Results Secured from Alphano-Grown Potatoes and Peas, to Which Are Added Some Convincing Photographic Proofs.

Page 13.

Success with Clay and Sandy Soils, Along with Some Help Hints About Growing Hollyhocks.

Page 14.

Your Shrubs and Trees—What Alphano Will Do for Them.

Page 15.

Tree Planting and Feeding—Four Helpful Hints.

Page 16.

Rhododendrons—Why Alphano Makes a Happy Home for Them.

Page 17.

Your Potted Plants and Window-Boxes. A Sure Guide to Their Success.

Page 18.

For Reseiling Purposes—The Part Alphano Should Play.

Page 19.

The Greenhouse and the Way Alphano Is Revolutionizing Growing Methods.

Page 20.

Soil Inoculation. An interesting Explanation, to Which is Added Some Convincing Facts About Alphano Inoculant.

Page 21.

A Cheap, Sure Method of Multiplying the Value of Your Compost Heap, in Addition to Which There are Some Interesting Facts About Alfalfa and Timothy Growing.

Page 22.

Expert Advice on Soils and Grass Seeds, Besides a Suggestion for Securing a Soil and Humus Tester.

Page 23.

Prices, which are Accompanied by the Usual Terms—Method of Shipment and Akin Facts Which You Always Want to Know.

Page 24.

An Invitation to Visit Our Plant. Kindly Consider This Especially Directed to Yourself and Friends.

Dr. Milton Whitney's Convincing Statement

DR. MILTON WHITNEY, Chief of the U. S. Soil Bureau, in Bulletin No. 55, page 51, in speaking about chemical fertilizers and those of organic origin, says:

> "It would seem that for the greater number of soils the most efficient fertilizers of the future will be of organic rather than mineral origin, provided that when such a substance is found it can be obtained in sufficient quantity; and at a sufficiently low cost, and be at the same time less bulky to ship than stable manure."

Alphano Humus is such an organic fertilizer—and more.

Caution

For your protection, insist on ALPHANO when ordering Humus. Others offered under the name "Humus," bearing various trade designations, are apt to be mere swamp muck. These may not be worth $2.00 a ton, and of little or no plant food value; perhaps even harmful to plant life.

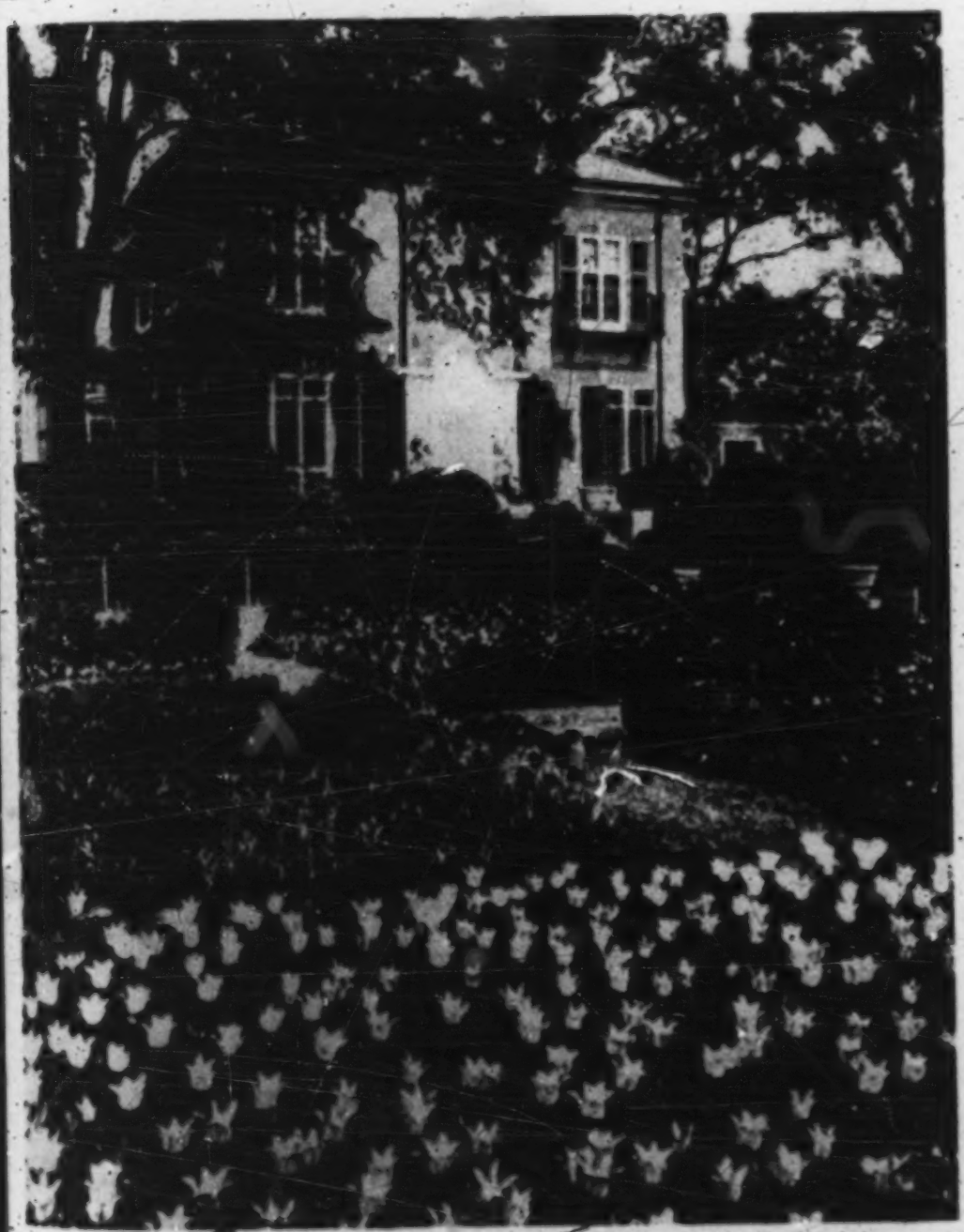
Guarantee

Take no chances. Ten years experience of thousands of satisfied Alphano users is your guarantee.

We stand back of every word we say, and every promise we make.

Alphano must and positively will give results.

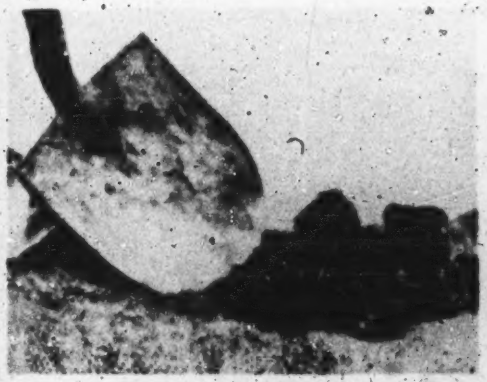
Enjoy the good results it is bound to bring to your lawn, shrubs, garden and greenhouse.



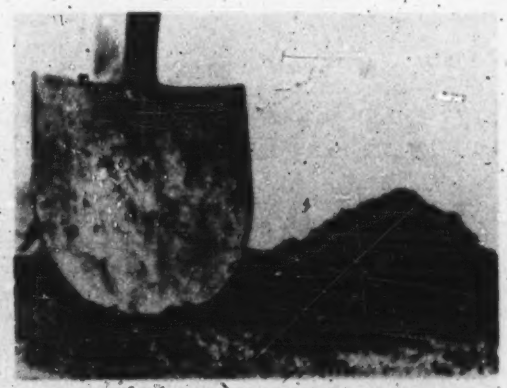
What is there which comes closer to our hearts in the early Spring than a garden like this, glorious with its bloom-coloring of tulips?

Their flowering period is short, but right up to the first of August growth is going on down in their bulbs. Upon the food and strength then stored up mainly depends their Spring bloom abundance. **Enrich them well with Alphano, as soon as the flowers are spent.**

This famed Long Island garden has luxuriated in Alphano for a number of years.



This lumpy, packy soil needs humus. Such soil is difficult to till, stays lumpy and lacks productiveness. It is made up of too much clay, and too little decayed vegetable matter, or humus.



The same soil, a week after being mixed with Alphano, which is rich in humus. Note how friable it is. Gardening with free working soil like this doubles both the pleasure and productiveness.

A Short Talk On Soil Needs

SOILS and people are a deal alike. No matter who we are, or what our work is, there must be in our food certain proportions of certain life-giving elements, else our blood becomes impoverished.

When a soil fails to produce it is because of either lack of food or food unfitted for the plants' needs.

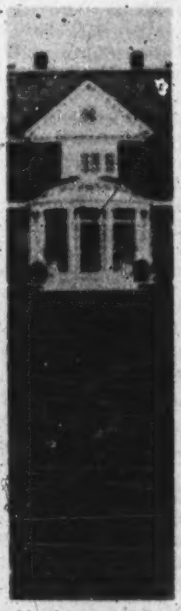
The first thing to find out about your soil is whether it is acid or alkaline. If acid, it needs sweetening with lime. We will gladly tell you a simple, quick way to find this out. See page 22.

It is a well understood fact that the great difference between sterile subsoil and fertile top soil is the difference in the humus they contain. It's apparent, then, that humus is the very backbone of soil productiveness.

Decayed vegetable matter is crude humus.

Barnyard manures, in addition to their plant foods, contain a percentage of humus, but their food values are widely variable and their use disagreeable and far from sanitary.

To use continuously the concentrated foods in the form of mineral fertilizers alone is not advisable, but when mixed with sufficient humus they become ideal.



One thing Alphano will produce in a surprisingly short time is a thick, vigorous sod, that will withstand a large amount of dry weather.

One of the chief values of humus is that it makes a perfect home and breeding place for the bacteria so necessary to fertility. These bacteria have a way of attacking the minerals locked up in the soil and converting them into a form available to the plant roots. Their activities also keep the soil open, so the air can work down through it, keeping it sweet.

Humus also has a way of absorbing four or five times its own weight in moisture, which acts like a big sponge in the soil. As a dry weather resistant, it is therefore decidedly valuable.

From all this it is evident, then, that the ideal soil builder would be one *rich in humus*, mixed with the essential plant foods and lively with the food liberating and nitrogen gathering bacteria.

Just such a soil builder is Alphano.

It is a perfectly balanced ration, prepared all ready for use. It is good for practically every growing thing.

This lawn was scattered with those old-fashioned flower beds once so much used. Last Spring, the owner, Mr. G. B. Richardson of Suffern, N. Y., planted them to grass, the soil being previously mixed liberally with Alphano. Four weeks later this photograph was taken. The only way you could detect the new grass was by its pronounced vigor and richness of color.

Natural Humus—An Explanation And A Caution

NATURAL Humus deposits are formed by the accumulation of countless years of decayed vegetable matter subjected to heat and moisture highly favorable for bacterial action. **Rich available deposits are of rare occurrence in nature.**

Deposits of peat and swamp muck, however, **are very common. They are made up of highly** acid organic matter, produced under conditions unfavorable to decay. **Such materials** should never be used as a soil builder. Their acidity and resistance to decay **make them entirely unfit for** plant food and *a distinct danger to plant life.*

At Alphano, N. J., there is a wonderful deposit of humus so free from acid and so rich in plant foods that when properly drained and deeply cultivated it at once produces abundant crops. This proves this particular humus to be ideal for soil-building purposes.

The humus we use as a basis for our Alphano comes from this remarkable deposit. It is first cultivated to prove its fertility and free it from all weed seeds, then it is electrically dug, beaten in fine pieces, aerated, sun-sweetened and dried and put in big piles, where it stays for months to further cure and multiply its soil bacteria before going through the concentrating and mixing process.

For your protection here is a comparison line-up of swamp humus and ALPHANO Humus.

SWAMP humus is generally acid and liable to be injurious to plant life.

ALPHANO Humus is sweet, and highly beneficial to plant life.

Swamp humus contains no soluble plant foods.

ALPHANO Humus contains all the soluble plant foods, such as nitrogen, phosphate and potash.

Swamp humus is harsh, wet and lumpy.

ALPHANO Humus is mild, dry and finely powdered, fit for broadcasting or using in drills.

Swamp humus is lacking in the good forms of soil-building and nitrogen gathering bacteria.

ALPHANO Humus contains all the good forms of legume and independent nitrogen gathering bacteria so essential to all soil fertility.

Swamp Humus contains approximately 1600 lbs. of water and only 400 lbs. of organic matter to every ton.

ALPHANO Humus contains approximately 1400 lbs. of actual humus matter to every ton. One ton of ALPHANO is equal to nearly four tons of swamp humus in its organic matter alone.

With these figures before you, you can see for yourself that swamp humus is worth only $2 per ton compared with ALPHANO at $8 per ton, when reckoned on the basis of the humus material alone.

ALPHANO contains so many more good things that there really is no comparison between the two.

It is a complete organic fertilizer and soil builder, carrying humus, lime, nitrogen, phosphate, potash and all the essential soil-building and nitrogen gathering bacteria.

Alphano—Its Strong Points

AFTER reading about Natural Humus on the opposite page, we can quickly explain to you exactly what Alphano is.

After the sun sweetened, aerated, Natural Humus has composted for several months, greatly multiplying its supply of soil building bacteria, we concentrate it in huge drying drums, requiring several tons of the Natural Humus to make one of the Alphano. Then it goes to the mixing room and liberal quantities of rich plant food nutrients are added to bring it up to a high fertilizing value.

This is followed by a liberal inoculation with our Alphano Inoculant, introducing in it all the essential nitrogen gathering bacteria that are so valuable for peas, beans, clover, alfalfa and such legume growths. See pages 20 and 21 for particulars of inoculation.

Now it is full fledged Alphano—a perfect soil builder, giving both immediate results and producing long enduring fertility.

Because of the abundance of humus it contains, Alphano will make a heavy soil lighter and a light soil heavier.

It breaks up compact, clayey soils, and binds together loose, sandy ones.

Because it absorbs so many times its own weight in moisture, it acts as a sort of internal reservoir, fortifying your lawn, flowers and vegetables against drying out.

Being rich in those foods that are *at once available* to the roots, results are immediate.

Being rich in those foods that are *slowly available*, its benefits continue for a surprisingly long time.

Being *so lively* with the soil building and nitrogen gathering bacteria, it attacks the locked up foods already in all soils, draws nitrogen direct from the air, and gathers it in nodules on the leguminous root growths, and in these ways further adds to and prolongs its benefits.

As satisfactory as are the results of Alphano the first season, its effects show even more the second. Alphano not only stimulates and furnishes food for your soil, but builds it up for years to come.

In addition to Alphano's building qualities, there are its distinct advantages of being *odorless*. You can use it *any time, anywhere*, without objection.

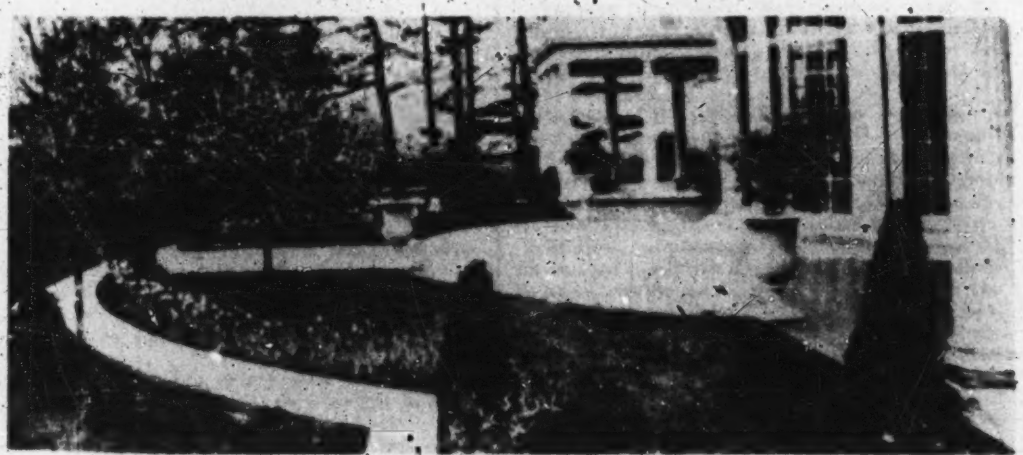
Its finely granulated form makes it easy to mix thoroughly with the soil, so that even the very finest of rootlets can be at once benefitted. It can be put on your lawn, raked in and *all* left there instead of being *raked off*, as is necessary with stable littered manures.

Being free from weed seeds it entirely overcomes one of the greatest objections to manures for lawns and gardens.

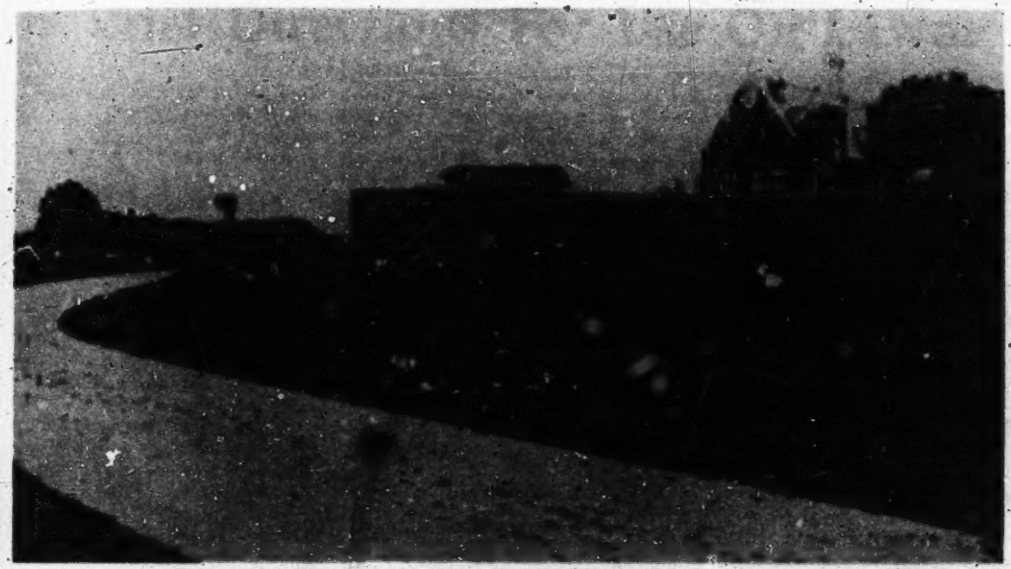
Being entirely free from plant diseases, maggots and other insect pests to which manure is heir, Alphano may be used with perfect safety on vegetable and flower gardens alike. You need never fear that Alphano will bring to your home, human or animal diseases such as are so commonly carried by manure; a few of which are typhoid, hoof and mouth disease, hog cholera, black rot, and such menaces.

Being so reasonable in price, you can use it freely all the season through.

For prices, see page 23.



It would be nothing short of a crime to litter this beautiful typical suburban residence with unsightly, unsanitary, fly-breeding stable litter. In its place Alphano is used, which is richer in plant foods, odorless and clean as sand.



Here is an interesting and conclusive bit of evidence of what Alphano will do for a terrace—the most difficult of all grassing problems. The top of the lawn was covered in the Spring with the usual heavy coat of stable manure. The terrace part with Alphano. The stable litter was of necessity soon *raked off*. The Alphano was *raked in* and became a direct part of the soil. The photo was taken three months later. The grass had been mown three days before. The difference in color and height of grass tells its own story of Alphano improvement.

What Alphano Does For Lawns Tennis Courts · Golf Links

IN the British Isles, where rains are frequent and "dampish" days come often, the grass forms in a compact, deep turf, having a rich green to the eye, and a delightful springiness to the foot.

Nowhere do you see finer lawns. To duplicate them in this country has generally been considered a great expense, and therefore indulged in only by the fortunate few.

The results secured, however, in the last ten years with Alphano prove that if climatic conditions are not so favorable as in England, practically the same results can be secured at a low cost, by building up such soil conditions as will be most fortunate for not only thick mats of "cushiony" *surface* roots, but induce a *deep*, vigorous root growth as well.

Of first importance, then, is to put into the soil something that will act like a hungry sponge, which, filling full of moisture, gradually liberates it as needed.

Alphano, with its rich humus base, absorbs from four to five times its own weight in moisture, meeting that requirement perfectly.

Its quickly available foods are an immediate stimulant to the top roots, while the slowly liberated foods, becoming a direct part of the soil, are in part carried deeper, inducing the larger roots to readily follow. This deep root growth in itself is a protection against dry weather.

Alphano overcomes that compact, unyiving condition of clayey soils, inducing a springiness. On sandy soils it binds the particles together, giving it a body and stability for the roots to hold themselves in.

Because of the offensiveness and unsightliness of stable manures, lawns that otherwise should each year be enriched are often neglected for two or three seasons, and so the soil foods are spent. The frequent close cutting also rapidly exhausts the soil, making life a weary grind for the roots.

Odorless, weed-seedless Alphano, because of its ease of application and freedom from offensiveness, can be used at any time, and with the first cutting of grass be entirely out of sight. But it's there, just the same, busy root building.

We were recently fortunate in securing the services of an intensely practical man on lawns, to write for us a book, entitled "Lawns and Golf Greens, Their Care and Fare." If you want to go into the question thoroughly, drop us a line and we will gladly send you the book with our compliments.

Brief Directions For Use On Lawns

They are brief because this question of lawn making and repairing, for example, is so big that to do it justice needs a book all to itself, so we only touch on it here. But our book on "Lawns and Golf Greens Their Care and Fare," you are welcome to. We suggest your sending for it. It covers the ground concisely and completely.

Old Lawns

DECIDEDLY contrary to general impression, it is not necessary to tear up an old lawn in order to get a satisfactory result.

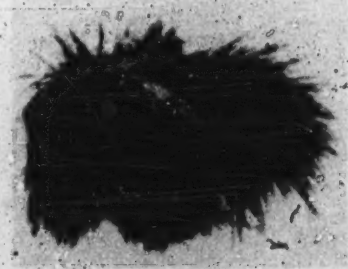
For every 1000 square feet of fairly good soil use at least two 100-lb. bags of Alphano. For poor soil five bags.

Rake or disk harrow every part of the lawn over deeply. Thoroughly spread on the Alphano. Rake or harrow in well. Mix 8 ounces of English rye grass with every pound of your seed mixture to act as a nurse. It will come up quickly, grow rapidly and protect the finer grass from the sun and when closely cut makes a satisfactory lawn in itself.

Use at least 2 to 3 lbs. of seed to each 1000 square feet for re-seeding. Or 3 to 5 lbs. in making new lawns.

Sow your seed first lengthwise and then crosswise to get an even distribution. Now roll it. If planted in Spring, grass will show in 10 to 15 days. In the Fall, after 5 to 10 days.

This 4½-inch deep sod was made in six weeks from the sowing of the seed. The soil was a regular sterile white sea sand, mixed with one-half Alphano.



Bottom view of the piece above. Notice the thick mass of fine rootlets, indicating the height of vigor and drought-resisting power.

A light top dressing of two-thirds soil and one-third Alphano will be highly beneficial after six weeks.

New Lawns

IF you want to go right to the bottom and make your old lawn entirely over, then deep spade it, or plough where possible. Do it so well that all sods will be *entirely buried*. Follow with raking or harrowing. Spread on Alphano at the rate of 800 lbs. to every 1000 square feet for ordinary enrichment, or up to 400 lbs. for long enduring fertility, with little or no after treatment. Rake in, seed, roll.

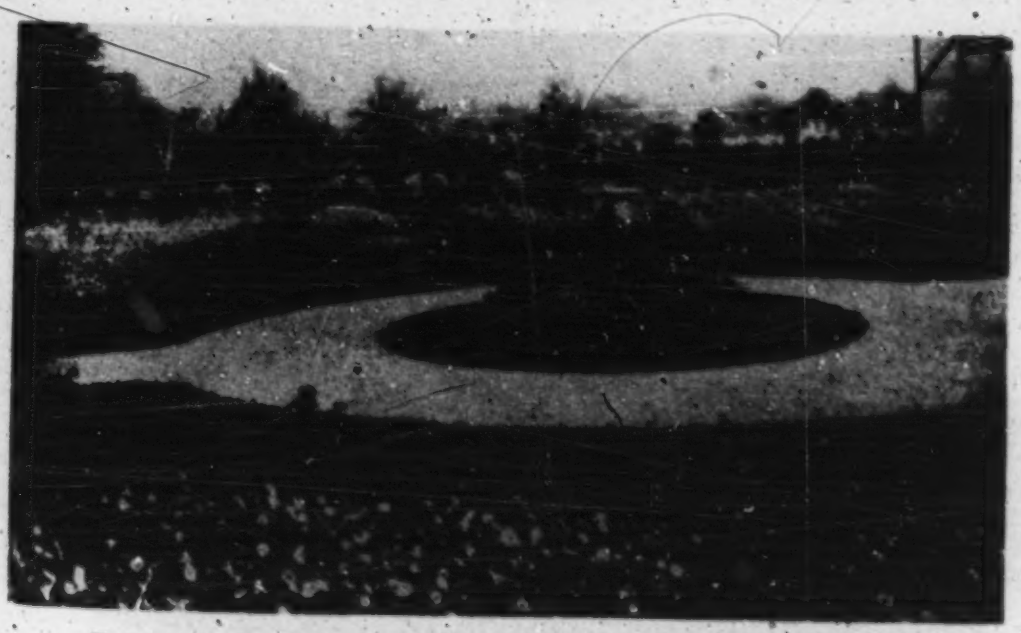
If your lawn site is one newly graded the chances are the soil is mostly sub-soil and practically devoid of humus. In which case after smoothing up you should use at least 200 lbs. of Alphano to every 1000 square feet, then follow the same as above.

In six weeks make a mixture of two-thirds soil and one-third Alphano and spread on lightly, using say 100 lbs. of the mixture to every 1000 square feet.

Spread the Alphano on with a shovel, then rake it over evenly, followed by *surely raking it in thoroughly.*

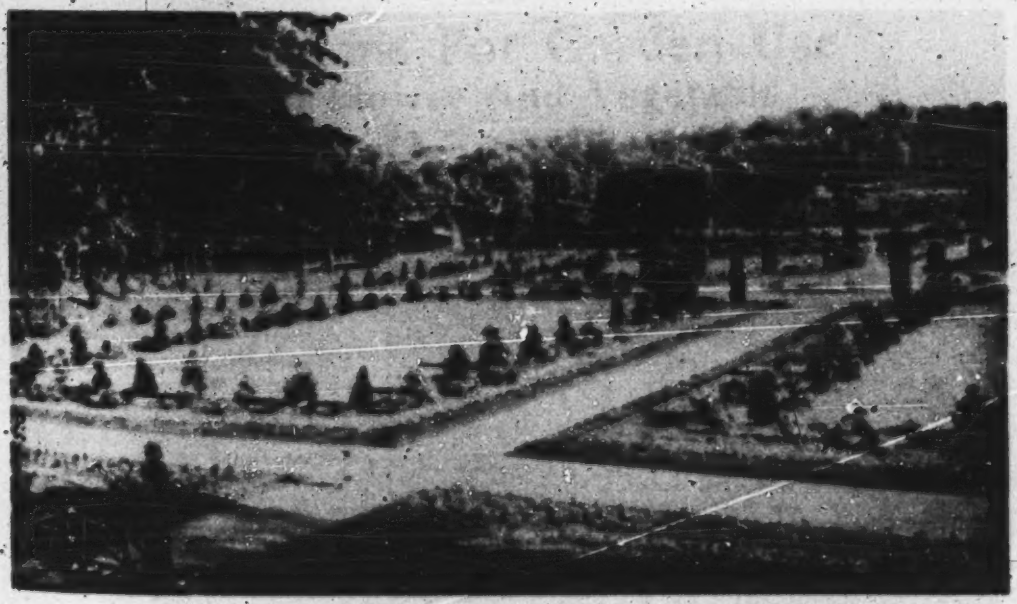
If you fail to rake this top dressing thoroughly into the soil, results will not be so good; in which case blame yourself—not Alphano.

Early in June this grass was thin and dotted with bare spots. It is approximately 60 feet long and 30 feet wide. Eight bags of Alphano were used. On the 15th of July, when this photograph was taken, it was fast becoming a perfect lawn.



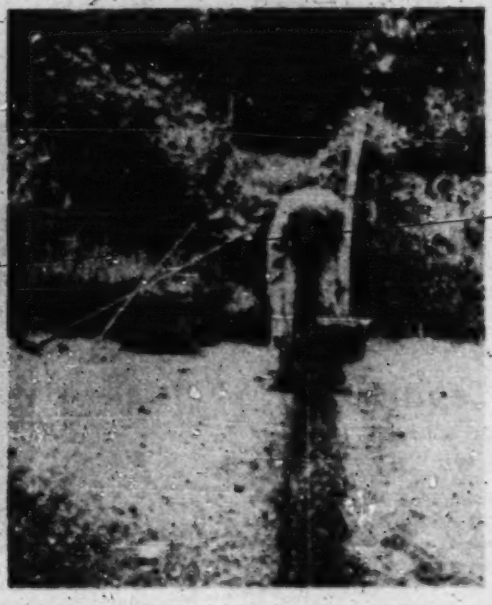
The light, sandy, Long Island garden soil on Mrs. A. M. Booth's grounds at Great Neck, L. I., was converted into a soil of ideal texture and wonderful productiveness by a season's use of Alphano.

Up in the mountains near Tuxedo, N. Y., where the soil is thin and the stones many; this extensive formal garden was made possible by the liberal use of Alphanu. The grass walks of this garden must certainly vie with those of England's famed "300-year-old turf." Name of owner gladly given on request.



Starting with a boggy swale, the City of New York had this piece of ground filled in with all sorts of city refuse and topped with a mere two feet of good field soil, lacking in humus. Tons of Alphanu were finally used and this Van Cortlandt Park, beauty spot burst into greenery and bloom. Samuel Parsons was the landscape architect.

Showing the raking in of Alphamo, after your garden has been spaded up and smoothed off. Use 300 pounds or more for every 1000 square feet.



Putting the Alphamo in the row before sowing the seed. It's always a good plan to do this. It insures the first roots getting plenty of nourishment, just *when they most need it.*

Directions For Garden Use
Both Flower And Vegetable

THERE are at least four ways you can garden happily and effectively with Alphamo:

1. Spread it on the soil and spade in, just like is done with stable manures.

2. First spade up, smooth off and then spread on the Alphamo and rake it in well. See illustration.

3. Sow in the row or hill, mixing it with the soil and then plant your seed. See illustration.

4. Dig it around the plants once or twice during the season to give them a good, vigorous boost.

If your garden soil is in badly impoverished condition and you want to surely have a model garden the very *first season*, you could well adopt all four ways.

If in fair shape, 2, 3 and 4.

If a good, friable, rich soil, then 2 and 3.

If you have at times been a bit boastful of your garden prowess, after using Alphamo you will surely be in a position to make your neighbors still more envious.

If your garden is a large one, and you don't feel like spending enough the first year to entirely rebuild the soil, then follow numbers 3 and 4.

Being odorless and in granulated form, Alphamo is an agreeable, sanitary solution to all your garden enriching problems.

The second year after you have adopted Alphamo as your garden helper you will have even better results than the first.

The busy millions of bacteria will then have had a better chance to get in their work and the Alphamo, will also by your season's tilling be more evenly mixed with the soil.

After Alphamo has once brought your soil up to a point of high fertility, it will be an easy matter to keep it there.

For Peas and Beans

Peas and Beans being legumes, the nitrogen gathering bacteria with which we inoculate Alphano will form nitrogen filled nodules on the roots, greatly increasing the rapidity of growth and quantity of yield.

These root nodules left to decay in the soil, at the end of the season, contribute liberal amounts of nitrogen for the benefit of any next season's crop.

For Sweet Peas

If you have had disappointments with Sweet Peas, the results from using Alphano will make your heart glad. Sow it freely in the drill.

Don't make the mistake of hoeing the soil up around the stems. It is liable to cause stem rot. Frequent loosening up of the soil, however, is essential.

The surprising thing about this celery is that it grew on a heavy clay upland soil that the year before refused to grow beans more than four inches high. When such soil can be induced the next season to grow celery 3½ feet from root end to top tips, it shows rather conclusively what Alphano will do if given a chance. Three inches were spread on and mixed in. Name of owner on application.

Setting Out Plants

Many of the uncertainties of plant setting out are overcome by the use of Alphano.

Mix it well into the soil so it will surely come in direct contact with the rootlets. Its readily available foods will promptly stimulate growth, while its property of retaining moisture cuts down to a minimum, weak backs caused by wiltings.

Boostings

Along the middle of Summer when all growth has drawn so on the soil foods, your plants will welcome the boost Alphano will give them if dug around their roots.

Being in dry, granulated form, you can do it easily and quickly. Being odorless, absolutely sanitary and clean as sand, its use is free from all objections.

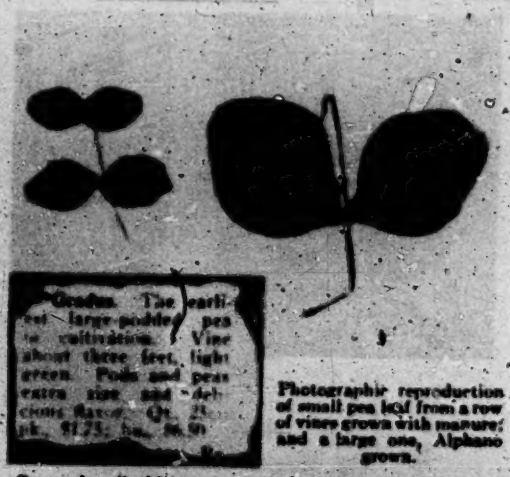
Started Aug. 4, digging Alphano around the plants. Photo taken in the early spring.

Same view of the same garden, even to the same enthusiast. Photo taken last of July, same year.

Results With Peas

ON June sixth of last year, Mr. B. T. Joyce of West Haven, Conn., wrote us the following:

"Just to let you know what Alphano Humus is good for in my garden. I used four bags on seventeen rows of Peas, each row 135 feet long. I planted them five weeks later than some of my neighbors. I have vines 4 feet high and they are only supposed to grow 3 feet high. Enclosed find a clipping from the seed catalog and two samples of leaves, the large leaves from my garden and the small from a neighbor's where horse manure was used. I also have Peas as large if not larger than other Peas planted five weeks earlier. A picture would be the only way I could prove it to you, but if you examine the leaves it will help to convince you." (Signed) B. T. Boyce.



Photographic reproduction of small pea leaf from a row of vines grown with manure; and a large one, Alphano grown.

Pea as described in catalog.

Three Times The Quantity Of Potatoes

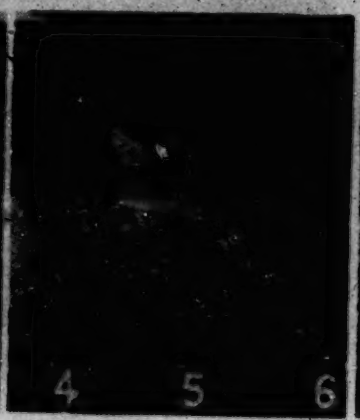
THE wording of the declaration below is taken from the affidavit of Mr. C. W. Baines of Newport News, Va., dated July 8, 1915, made before H. H. Noblus, notary public and now on file at our office.

Newport News, Va., July 8th, 1915.

"I, C. W. Baines, hereby certify that the below is an actual photograph of six (6) rows of Irish Potatoes which I raised on my trial grounds. The rows numbered 4, 5 and 6 were treated with commercial fertilizer ($45 per ton), while those numbered 1, 2 and 3 were treated with a like amount (not value) of Alphano Humus."

To secure that freshly succulence so delicious in lettuce perfection, it must be grown quickly. That's one of the things Alphano makes possible. It has the properties of inducing a quick growth, as well as a solid one. For coldframe use, it is ideal.

Rows 1, 2 and 3 were given same amount of Alphano at $12 a ton, as rows 4, 5 and 6 with chemical fertilizer at $45 a ton.



Rows 4, 5 and 6, in spite of using a fertilizer nearly four times the cost of Alphano, made poor growth.

Potatoes in left hand pile came from row No. 2. The right hand one from row No. 4.

This suburbanite had come to the conclusion that he never could have a successful flower garden with his lumpy, pasty soil. One year he gave it up altogether. Year before last he tried it again by using Alphano. From the results this photograph shows, it is not to be wondered that he has become a real gardening lover. Name gladly given on request.

We have yet to find the flower that does not thrive vigorously with the use of Alphano in proper soil mixtures. On an extremely light, sandy Long Island soil, it each year produces this continuously beautiful garden. It seems to bloom earlier and last longer than other nearby gardens.

So far, there is nothing we know of that will prevent leaf rust on Hollyhocks. It is a noticeable fact, however, that good, vigorous, quick growing plants are least affected. Dig Alphano liberally around the roots and give them a try. Results will surprise you.

For Your Shrubs and Trees

DON'T slight your shrubs and trees when it comes to enriching your lawn and gardens. It's surprising the response you will get from them for such "encouragement."

Shrubs that have been growing slowly and blooming indifferently will take on a new lease. Before the blooming time is a good time to use Alphapo as it increases their size. A month or so after, is also a good time as the shrubs are then often exhausted by the blooming. May and June are the months when both trees and shrubs make their growth. The rest of the Summer the growth then made is hardening up to withstand the Winter.

That the roots should have ample food during this period of greatest growth is obvious. Another thing to remember is that many of the shrubs bloom next season *on only the new growth made this.* Abundant growth this season means abundant blooms next.

The result of Alphapo used on Golden Privet. The roots at the left of the line were the original ones. Those at the right are *all new.* Their growth was induced in one season, entirely by the use of Alphapo. Vigorous root growth means flourishing tops. Most shrubs are great feeders. Slight their food and your results will be proportionate.

Don't put a scanty shake of Alphapo around your shrubs and then dig it in gingerly. First make the ground nice and mellow all around the roots for a goodly distance, and then dig plenty of Alphapo well in. Once or twice during the season, loosen the earth up. Given even half a chance, shrubs respond wonderfully.

Tree Planting and Feeding

When planting your shrubs, start right by using Alphano with water, make a semi-liquid mixture of two-thirds soil and one-third Alphano and stick the roots into it, or plaster it thoroughly on them. It moistens them and furnishes an immediately available food to bridge over the time until they get a grip on the soil.

Spread the roots out well, as all directions, make sure the tree stand straight and then fill in with dirt mixed with at least a third of Alphano. Be sure to pack tightly immediately around the roots, so they can quickly get a hold on the soil fresh. Loosen the top soil at least twice during the season. Each year top dress with Alphano and dig in well. If you want maximum results this is the way to get them.

Some think that because evergreens generally come packed with a ball of their native earth around their roots they need no enriching the first season. Transplanting at best is always an ordeal for any tree. A quick recovery means quick growth. Make their food rich and easy to reach. Plant them with soil mixed with at least one-third Alphano.

The fine food-absorbing rootlets of trees are at the ends of the larger roots. To dig Alphano around close to the trunk of a tree helps a little; but to secure the greatest benefit, it is necessary to go out as far as the branches extend and then dig a circle trench around the tree; fill in with soil mixed with one-third Alphano. Do it thoroughly this way and then it's done for several years to come.

Rhododendrons on a famous New Jersey estate. Alphano was used by the carload on the lawns and around the flowers, shrubs and trees of this extensive estate.

Ideal For Rhododendrons

IN their native habitat, Rhododendrons are found growing in rich, humus-laden soil formed by decayed forest leaves.

The nearer then, you come to duplicating such soil, the finer will be your plants. Alphano's base being just such a rich, thoroughly decayed humus, it makes an ideal base for Rhododendrons when mixed with from one-half to two-thirds soil. In the Fall, bank them all around with leaves at least two feet deep, laying sticks or branches on them to prevent their being blown away. In the early Spring remove the leaves, mulch with Alphano, gently mix into the soil. The root mass is near the surface, so have a care not to dig too vigorously. See that they have plenty of water. They are no relatives of the Cacti family.

Do not lose sight of the fact that the Rhododendron buds for next Spring's blooms are formed at the end of the new May-June branch growth. It is a critical period for them. See that the roots have *ample food* and moisture. Mulch heavily with Alphano.

For Potted Plants And Window Boxes

HOW to either secure or make a proper soil mixture for window boxes and potted plants is an ever recurrent problem with many. Even if you are so fortunate as to start with a fairly rich soil it soon loses a large percentage of its foods by leaching away with the constant waterings always necessary.

Being confined in such limited spaces, the soil must be of an open, friable nature, to secure a free circulation of air. It must have body enough to hold the moisture but not so heavy as to keep the roots waterlogged. Almost any soil, heavy or light, can be converted into an admirable one for the purpose by a mixture of Alphano. For good garden soils one-quarter Alphano is sufficient. For poor soils, one third.

In addition to mixing the soil with Alphano, it is well to dig it some, once or twice during the season. Being odorless you can do this without objection at any time.

Straggly, leggy plants have no place in your window boxes. You want them stocky, and healthy *all the way through*. Soil mixed with one-third Alphano will give splendid results all Summer. A top dressing of it dug into the soil once or twice during the season will also be found decidedly beneficial.

The problem on this estate was to produce in two years, results that would give the effect of being established for fifty years. Extensive grading was done, big trees moved in, and large shrubs planted freely. To insure an immediate and lasting fertility, Alphano was used liberally. Here is a pile waiting distribution. Name of estate on request.

For Resoiling Purposes

IN grading and changing the conformation of grounds the question of fertile top soil is a serious one. The average depth of top soil is seldom over a foot. This soil contains the essential humus which plant life demands for its thriving.

The sub-soil is lacking in such humus. This being so, you can appreciate more than ever why it becomes such a difficult problem to secure satisfactory growing results on a piece of ground the grading of which has required the removal of soil from some portions and filling it in at others.

It is in just such cases that Alphano is of great value. By its use you can greatly increase the fertility of an already fertile soil and quickly make sterile sub-soils satisfactorily fertile.

Even seashore sand can be made productive when mixed with Alphano. The above picture, taken on a Long Island estate, shows one of several piles of Alphano amounting to 1700 tons, which was used in an extensive resoiling operation.

Before placing this 1700-ton order the owners had first convinced and re-convinced themselves of the merits of Alphano by giving it trying tests in locations where they could keep continual watch of the results.

One ton of Alphano contains nearly two yards of pure humus, or an amount equal to what is generally found in 40 to 50 yards of such soil as is usually sold for from $2 to $3 a yard.

It is self-evident that Alphano at $4.50 to $5 a yard is worth at least twenty times as much as ordinary soil in humus alone, not to mention the rich plant foods and beneficial soil bacteria it contains. An absolutely barren, sandy waste at Glen Cove, L. I., was in a season converted into a garden spot where vegetation now blossoms and flourishes like the green bay tree.

The Alphano for this estate was shipped in cars to Hoboken, N. J. and taken in barges up Long Island Sound to Glen Cove.

Use In The Greenhouse

THE intensely intensive methods employed in the successful greenhouse growing of flowers, fruits and vegetables require a soil of high fertility. The combination of artificial heat and conservation of the sun's rays by the glass causes an atmosphere which quickly dries out the soils. The problem of watering is one requiring great judgment. Too little causes the roots to struggle for moisture, retarding top growth; too much sours the soil, checking root growth.

As the season advances, especially with "strong feeding" plants, top dressings of either barnyard manures or bone meal were, before the advent of Alphano, necessary. Both of these are of offensive odor. The manure is obnoxiously unsightly, making the visiting of one's glass enclosed garden at such times anything but a pleasure.

On eight joints of these 3ft tall high Alphano fed tomato vines there are fruit clusters. One joint is in bloom and another forming buds. Nothing has ever approached Alphano in this man's experience with his former use of manure or other fertilizers. Name of grower on application.

If you are one of the fortunate flower lovers who enjoy showing your devotion to your flower friends by working among them yourself, such objections as these greatly discount your pleasure.

Alphano in proportion of one to three parts of soil makes a greenhouse mixture that is entirely free from odor. As an odorless top dressing it is highly resultful and without the objection of unsightliness.

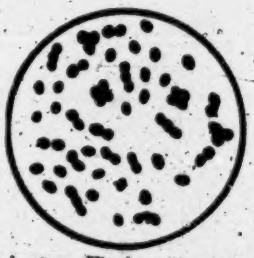
Being capable of absorbing many times its own weight in moisture, frequent watering is not necessary—in fact it is to be guarded against.

For making a potting mixture the gardeners tell us it is just about ideal.

Order some and try it out on one of your benches.

To be able to go into your greenhouse at all times and find it free from obnoxious soil enrichment odors, is one of the desirable things in favor of Alphano.

Photographic reproduction of a colony of Radicola, one of the busiest nitrogen-gathering bacteria, magnified one million times.



Azotobacter. The bacterium that fixes atmospheric nitrogen.

Root of crimson clover, showing the nitrogen nobs or nodules. They are filled with thousands and thousands of nitrogen-gathering bacteria.

Soil Inoculation and Something About Alphano Inoculant

Inoculated crimson clover grown with rye, which acts as a nurse crop.

ALL fertile soils contain what might be called natural bacteria that in their activities convert the soil minerals into forms readily available to plant life. They also do an important part in helping to keep the soils open so the air freely circulates through them. So minute are they that thousands, can lodge on the head of a pin.

Twenty or so years ago it was discovered that if soils in which clover had grown freely were scattered lightly over ground that failed to yield a satisfactory crop the production would be greatly increased.

Microscopic investigation and bacteriological tests proved that the little nobs or nodules on the roots of all Clover and other legumes are filled with nitrogen gathered from the air by certain nitrogen converting bacteria with which they were particularly lively. The abundant presence of these nodules always went hand in hand with large crops.

It was also noticeable that when the roots of clover, cow peas, vetch and like legumes were ploughed under the ground's fertility was greatly increased for subsequent crops of whatever kind.

Then followed the discovery that there were several legumes that had their own private bacteria, as it were, that would work only for them. Following this the various bacteria were isolated and by cultural processes, multiplied and sold for inoculating seed before being sown. When handled consistently the results were satisfactory. But the highly artificial medium in which the bacteria were held and shipped made their existence more or less uncertain and results from their use variable.

After a long series of experiments conducted by a well-known bacteriologist, of one of our foremost Agricultural Colleges; he discovered that our Alphano was an ideal home for all the legume bacteria. In the Alphano they multiplied with rapidity, gained great vigor and retained their vitality under conditions utterly impossible in the other mediums.

He also made the phenomenal discovery that the bacteria of all the legumes could be grown together in Alphano. The astounding fact also developed that this inoculated Alphano can then be used to inoculate the soil for any and all legumes. No longer is it necessary to buy a separate inoculant for each legume.

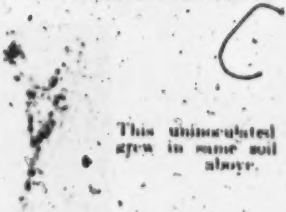
It is this all-in-one material, called Alphano Inoculant, with which we inoculate our regular prepared Alphano.

We are now offering it for sale in 2-lb. cans, sufficient for inoculating one acre, and in 20-lb. cans, enough for ten acres.

For full particulars send for the Alphano Inoculant Booklet.

For prices see over the leaf to page 23.

Inoculated soil grew this Alfalfa



This uninoculated Alfalfa grew in same soil as the above.

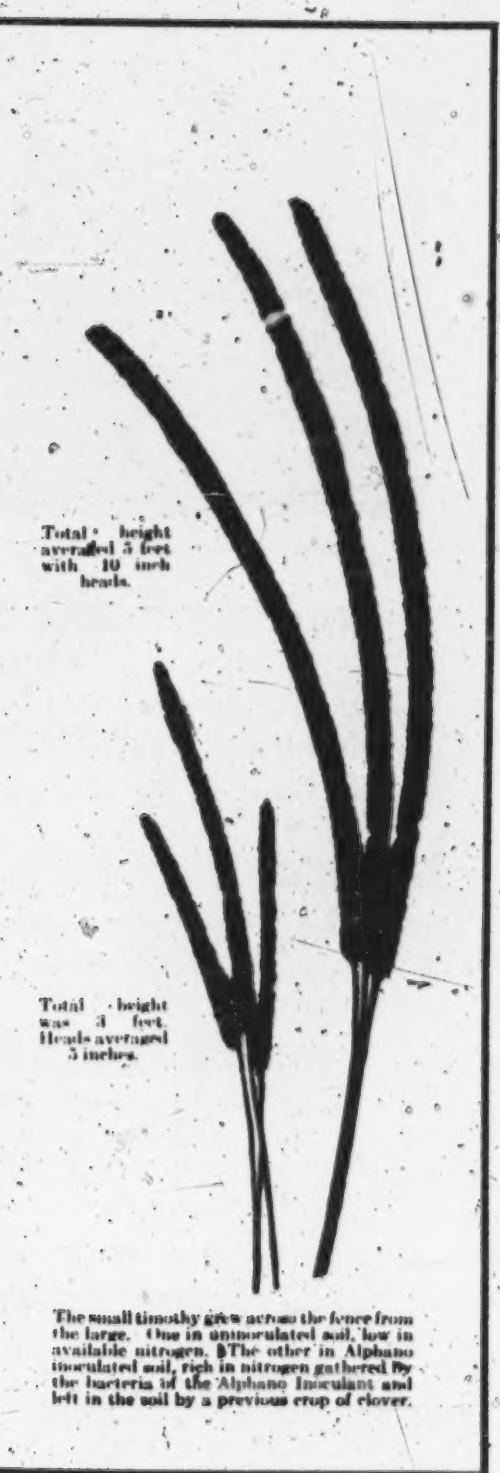
For Composting Use Alphano

THE mixing of Alphano with your compost heap will not only give a highly valuable increase in plant foods and humus, but bring to it countless billions of soil food converting; and nitrogen gathering bacteria, that will inoculate the entire compost heap and in turn any soil it is used on.

It is a sure method of increasing at a very low initial cost the quantity and fertilizing value of your compost.

Alphano may also be used to great advantage as an absorbent under the stable bedding, in the drops behind the cattle and in the poultry house. As an absorbent of liquid excreta it has several times the value of phosphate floats.

For inoculating purposes only, sprinkle the heap or loads as taken out with soil mixed with the Alphano Inoculant.



Total height averaged 5 feet with 10 inch heads.

Total height was 3 feet. Heads averaged 5 inches.

The small timothy grew across the fence from the large. One in uninoculated soil, low in available nitrogen. The other in Alphano inoculated soil, rich in nitrogen gathered by the bacteria of the Alphano Inoculant and left in the soil by a previous crop of clover.

This Alphano-ized garden and lawn make you think of the wonderful results for which England is so famed.

Free Expert Advice On Soils and Grass Seeds

MUCH time and no little money are wasted simply because people persist in ignoring the simple rules of cause and effect when it comes to questions about soils.

They will, for example, seed and re-seed acid soils and complain bitterly because they can't produce a satisfactory sod.

There is no use bumping up against Nature's rules, because she *always* does her return bumping vigorously.

Indulge her, however, and your reward is ample.

If you will fill out one of our soil question blanks and mail it to us, our experts will gladly advise you concerning the treatment and handling of any of your soil to secure its highest production fertility.

Based on this information, we can then also intelligently suggest the grass seed best suited to both your soil and climatic conditions.

If the soil question blank enclosed in this book has happened to slip out, let us know and we will gladly send you another.

Send For Soil and Humus Tester

FOR your own use you should surely have one of our Alphano Soil Testers, so you can with surprisingly little trouble quickly find out for yourself whether your soil is acid or alkaline and what its humus content is.

Along with the tester we will send you a guide that tells you exactly what to do under varying soil acidity and humus conditions.

An acid soil is just as detrimental to the health of most plant life as an acid stomach is to you.

Lime is the universal sweetener for soil. But the quantity used must, of course, be governed by the amount of acidity to be corrected.

This, the Alphano Soil Tester will tell you.

We will gladly send it to you, postpaid for $1, or send it with our compliments with an order for 5 bags or more of Alphano.

Prices

Alphano Humus

5 Bags, 100 lbs. each	$5
By the ton, in bags	$12 a ton
By the car, in bags	$10 a ton
In bulk, by car or barge load	$8 a ton

These prices are for delivery on board cars at Alphano, N. J.

Alphano Inoculant

2-lb. tins, enough for one acre	$1
20-lb. tins, enough for ten acres	$5

We prepay cost of delivery from our factory to all points east of the Mississippi when cash accompanies order.

Terms

CHECK, draft or money order should accompany all orders for less than two tons. Satisfactory references will, however, have consideration on orders for anything above two tons.

Method of Shipment

ALPHANO is usually shipped in bulk in carload lots. In less than carload lots, it is forwarded in bags. Special freight rates have been made by the various railroads from Alphano, N. J., to all principal shipping points. When transportation by water is practicable, barge-loads are delivered alongside nearest dock to customer's estate or beached upon the property itself if shore and weather permit. This effects considerable saving in freight charges. *Alphano Inoculant* will be sent delivery prepaid, east of the Mississippi when remittance for prices given in this book accompanies order.

Guaranteed Analysis of Alphano Humus

Chemical Element	Per Cent
*Nitrogen	1.25 to 2.50
Ammonia	1.50 to 3.00
Available Phosphoric Acid	.50 to 1.00
Potash	.50 to 1.00

Balance, Humus Vitalizers, Lime and Moisture.

*Humus Nitrogen.

These are our huge drying drums where the humus, after being aerated and composted is slowly concentrated with a mild heat which drives out 75 per cent of the moisture while still preserving its natural rich bacterial life

You Are Cordially Invited To Visit Our Works At Alphano, N. J.

WE want you to visit our works. They are located in the beautiful Pequest Valley, a scant six miles' auto ride from Hackettstown, N. J. Or you can reach it on the Lackawanna Railroad by way of Andover Junction and the Lehigh and Hudson River road. Also by taking the Erie to Greycourt and changing to the above road.

We want you to see the rare Alphano deposit of humus, with some areas still covered by growth primeval.

Glimpse along a stretch of our 10-mile private railroad. So luxuriant and abundant is the vegetation you almost feel you are in the midst of some tropical jungle

We want you to see the interesting process from start to finish of converting the humus into the wonder-working soil-builder, Alphano.

We want you to see the huge composting pile.

And if you are a little adventurous; you will surely want to go chug-chugging over to the western deposit in the engine of our own private railroad.

You will find such a visit interestingly instructive. You will leave, feeling amply compensated.

January, 1923 Bulletin 377

Results of Seed and Legume Inoculant Inspection for 1922

NEW JERSEY

AGRICULTURAL

Experiment Stations

Department of Seed Analysis

New Brunswick, N. J.

DEPTS. EX. 19 IDEN.

PART 2. LEGUME INOCULANT INSPECTION

Introduction[6]

In accordance with the law governing the sale of legume inoculants, passed by the New Jersey State Legislature in 1919, the market has been inspected and samples collected for official analysis. Considerable time has been spent in a successful attempt to remove from the market all old and out-of-date stock and in collecting the official samples. The samples as collected have been forwarded to the Experiment Station for purposes of official tests which have been conducted in accordance with the method outlined below. The results of these tests have been placed in Table 61.

The Legume Inoculant

The law defines the term legume inoculant as any material which contains the nitrogen-fixing organism, *Bacillus radicicola*, and which is sold, offered or exposed for sale for the purpose of conveying organisms of *Bacillus radicicola*. This law states that all preparations sold for this purpose shall bear a label giving the following information:

1. The brand name.
2. The kind or kinds of legume crops for which the contents may be used.
3. The month and year in which the inoculant was prepared.
4. Probable date beyond which inoculant would be of doubtful value.
5. Quantity of material in terms of amount of seed or acreage for which the contents may be used.
6. Name and address of manufacturer.

It is required, furthermore, that all persons or companies wishing to sell legume inoculants shall file with the Experiment Station annually a statement of the brand or brands that they wish to sell and the name and address of the manufacturers.

The penalty for violation of the law is a fine of twenty-five ($25.00) to one hundred dollars ($100.00) for each offense.

In addition to this regular control by means of official analysis the law provides that any citizen of the State of New Jersey may obtain, free of charge, a report on the examination and analysis of any sample or samples of legume inoculants. To secure these services it is only necessary to send the proper samples to the New Jersey Agricultural Experiment Station, transportation charges prepaid. These analyses are classed as unofficial. The results of tests of unofficial samples are published in the Forty-third Annual Report of the Experiment Station, 1921.

Analysis of Official Samples

The stock of the registered dealers (see table 60) has been inspected and found to be in good condition (see tables 61 and 62).

In table 62 are listed the test numbers of all cultures that gave either poor inoculation or failed to meet the purpose of the law in regard to their

[6]The inspection and analysis of legume inoculants has been conducted by Alfred T. Perkins, M.Sc.

labels. The exact reason for listing these cultures is indicated in table 61. However, it should be noted that the cultures, 246, 255 and 264, labelled "peas, beans and sweet peas," gave good inoculation for garden peas, garden beans, lima beans and sweet peas but failed in the inoculation of soy beans and cow peas, which require a different specific organism. It should also be brought to attention that cultures 255, 261, 262, 263 represented a stock of material manufactured in 1922 and withdrawn from the market immediately after inspection.

The methods in testing the cultures are in brief as follows: bacterial counts and purity tests are made and recorded. The cultures are diluted to the proper degree, applied to sterilized seeds, and planted in fertilized and sterilized sand. The pots in which the inoculation tests are conducted are kept in the greenhouse, where moisture and temperature can be controlled. Purity tests are not reported, since an impure culture is considered to be of the same value as a pure culture containing the same number of radicicola organisms.

The inoculation tests have been recorded as "O. K." which indicates good inoculation, as "Fair" or "Poor," which indicates a positive test, and as "None," which indicates no inoculation.

Attention is called to table 63, in which are grouped the several host plants inoculated by the same organism. It may be considered that a culture inoculating one plant of a group will inoculate the other plants in the same group.

As an aid in studying the figures listed in table 61 near the heading, "Number of organisms per acre," table 64 has been inserted, which gives the number of seeds of the leguminous plants commonly sown per acre.

Summary and Conclusions

The tables show that the market of legume inoculants is in good condition. During the year the stock of improperly labelled material has been reduced to a minimum. Since the cultures on the market all bear a date of manufacture and a guarantee of the time for which the cultures will remain viable, little more can be done except to run tests which will indicate whether or not the guarantee of the companies are fulfilled. The vast majority of such tests in the past have given satisfactory results.

Table 65 gives a summary of the cultures tested and table 66 the number of dealers in legume inoculants registered in each county of the state. From these tables it may be seen that the principal inoculants sold are those of the Earp Thomas Corporation and of the H. K. Mulford Co., while the principal area of their use is in south New Jersey.

OFFICIAL LIST OF REGISTERED DEALERS—TABLE 60

Dealer's Name	Address	Brands of Inoculants Registered
Andrewes Drug Store	Broadway, Salem	Mulford Culture
E. H. Berry	Toms River	
Blew & Blew	Bridgeton	Mulford Culture
Burlington County Supply & Produce Co.	Mt. Holly	Farmogerm
S. E. Burr Hdwe. Co.	Bordentown	
J. S. Collins & Son, Inc.	Moorestown	Mulford Culture
Geo. De Baum & Son	253 Main St., Hackensack	Farmogerm
Dixon & Fogg	Broadway, Salem	Mulford Culture
Farmer's Seed Store	38 S. Pearl St., Bridgeton	Mulford Culture
Alexander Forbes & Co.	115 Mulberry St., Newark	Mulford Culture Farmogerm
Ralph B. Gable	Landis Ave., Vineland	Mulford Culture
Hart & Co.	Paterson	Farmogerm
John Molitor	Swedesboro	Mulford Culture
Monmouth County Farmers' Exchange	Freehold	Farmogerm
Muzzy Bros.	143 Main St., Paterson	Farmogerm
Perrine & Buckelew	Jamesburg	Alphano Ino.
Martin C. Ribsam	Trenton	Mulford Culture Farmogerm
Jacob Rubinoff	Vineland	Alphano Ino.
Sharp, Alwater & Haver	Flemington	Farmogerm
H. K. Shoemaker	Swedesboro	Mulford Culture
So. Jersey Farmers' Exchange	Bridgeton	Alphano Ino.
Swedesboro Supply Co.	Swedesboro	Mulford Culture
Taylor Bros.	Front and Market Sts., Camden	Mulford Culture
A. Tepperman	Long Branch	
Tuohy & Lounspury	Market St., Salem	Mulford Culture
Geo. W. Weber	301 High St., Millville	Mulford Culture
Westrobac Sales Agency & Agents	Orange	Westrobac
Geo. H. Whipple & Son	63 Broad St., Bridgeton	Mulford Culture
Jacob R. Wyckoff	Princeton Junction	Farmogerm
W. H. H. Wyckoff Co.	33-35 Middaugh St., Somerville	Farmogerm

RESULTS OF OFFICIAL ANALYSES—TABLE 61

Test Number	Town Retail Vendor Wholesale Vendor	Crops and Inoculation		Organisms per package (Millions)	Organisms per acre (Millions)	Date of preparation Guarantee Date of test
	TRENTON					
236	Martin C. Ribsan Earp-Thomas Co.	Vetches	O. K.	735 1 acre	735	8-21-20 5 years 9-21-21
237	Martin C. Ribsam Mulford Co.	Soy Beans	O. K.	1,400 1 acre	1,400	5-19-21 1 year 9-19-22
281	Martin Ribsam Earp-Thomas Co.	Red Clover	O. K.	12,760 3 acres	4,253	1-10-22 5 years 5-9-22
282	Martin Ribsam Mulford Co.	Red Clover	O. K.	304,500 5 acres	61,000	4-1-22 1 year 5-9-22
277	Martin Ribsam Earp-Thomas Co.	Red Clover	O. K.	6,597 1 acre	6,597	3-8-22 1 year 5-9-22
278	Satterthwaite's Seed Store Earp-Thomas Co.	Red Clover	O. K.	86 3 acres	29	3-9-22 5 years 5-20-22
279	Satterthwaite's Seed Store Earp-Thomas Co.	Alfalfa Swt. Clover	O. K.	1,100 3 acres	366	1-10-22 5 years 5-9-22
280	Martin Ribsam	Garden Beans	None	327 Garden Size		3-4-22 1 year 5-9-22

RESULTS OF OFFICIAL ANALYSES—TABLE 61—Continued

Test Number	Town Retail Vendor Wholesale Vendor Commercial Name	Crops and Inoculation	Organisms per package (Millions)	Organisms per acre (Millions)	Date of preparation Guarantee Date of test
	VINELAND				
274	Shenberg & Rubinoff Alphano Humas Co.	*All Crops* Soy Beans O. K. Garden Beans O. K. Alsike O. K. Alfalfa O. K. Vetch O. K. Lupines O. K.	1,408 1 acre	1,408	3-8-22 1 year 5-20-22
275	Ralph Gable Mulford Co.	Alfalfa O. K.	4,745 5 acres	949	4-24-22 1 year 5-9-20
276	Ralph Gable Mulford Co.	Soy Beans O. K.	2,934 5 acres	587	4-24-22 1 year 5-20-22
240	Shenberg & Rubinoff Alphano Humas Co.	*All Crops* Cow Peas O. K. Soy Beans O. K. Garden Beans O. K. Alsike O. K. Alfalfa O. K. Vetch O. K. Lupines O. K.	8 1 acre	8	8-13-22 1 year 9-13-21
	MOUNT HOLLY				
241	Burlington County Supply & Produce Co. Earp-Thomas Co.	Vetches O. K.	113 1 acre	113	Not given 5 years 9-14-21
242	Burlington County Supply & Produce Co. Earp-Thomas Co.	Alfalfa O. K.	185 1 acre	185	8-16-21 5 years 9-14-21
	FLEMINGTON				
243	W. H. H. Wyckoff Earp-Thomas Co.	Garden Peas O. K.	9 Garden Size		4-14-21 5 years 11-2-21
	FREEHOLD				
266	Monmouth County Farmers' Exchange Earp-Thomas Co.	Red Clover O. K.	792 3 acres	264	2-4-22 5 years 5-20
267	Monmouth County Farmers' Exchange Earp-Thomas Co.	Alsike O. K. Clover	1,490 3 acres	496	2-4-22 5 years 5-9-22
268	Monmouth County Farmers' Exchange Earp-Thomas Co.	Alfalfa O. K. Swt. Clover O. K.	23 1 acre	23	2-4-22 5 years 5-9-22
	ORANGE				
269	Western Soil Bacteria Agency Western Soil Bacteria Agency	Garden Bean O. K.	77 1 acre	77	Not given G. until 7-18-22 5-20-22
270	Western Soil Bacteria Agency Western Soil Bacteria Agency	Alfalfa O. K.	638 1 acre	638	Not given G. until 7-18-22 5-20
271	Western Soil Bacteria Agency Western Soil Bacteria Agency	Red Clover O. K.	1,050 1 acre	1,050	Not given G. until 7-18-22 5-9-22
272	Western Soil Bacteria Agency Western Soil Bacteria Agency	Cow Peas O. K.	7,590 1 acre	7,590	Not given G. until 7-18-22 5-20-22
	SALEM				
253	Dixon & Fogg Mulford Co.	Alfalfa O. K.	340 1 acre	340	8-18-22 1 year 3-17-22
	CAMDEN				
238	Taylor Bros. Mulford Co.	Vetch O. K.			7-21-22 1 year 9-14-22
	SWEDESBORO				
239	H. K. Shoemaker Mulford Co.	Alfalfa O. K.	8,000 1 acre	8,000	8-30-22 1 year 9-19-21

RESULTS OF OFFICIAL ANALYSES—TABLE 61—Continued

Test Number	Town Retail Vendor Wholesale Vendor Commercial Name	Crops and Inoculation		Organisms package per (Millions)	Organisms per acre (Millions)	Date of preparation Guarantee Date of test
	MORRISTOWN					
251	Geo. Loeser Western Soil Bacteria Co.	Vetch	O. K.	78,675 1 acre	78,675	Not given G. until 2-7-22 11-14-21
252	Geo. Loeser Western Soil Bacteria Co.	Lupine	O. K.	12,150 1 acre	12,150	Not given G. until 2-7-22 11-22-21
250	Geo. Loeser Western Soil Bacteria Co.	Alfalfa	O. K.	16 683 1 acre	16,683	Not given G. until 2-7-22 11-3-21
	NEWARK					
244	Muzzy Bros. Earp-Thomas Co.	Alfalfa	O. K.	74 Garden Size	74	4-10-22 5 years 10-19-21
247	Alex. Forbes & Co. Mulford Co.	Garden Peas	O. K.	4 Garden Size		5-25-21 1 year 11-2-4
248	Alex. Forbes & Co. Mulford Co.	White Clover	O. K.	65 1 acre	65	5-2-21 1 year 11-2-21
249	Alex. Forbes & Co. Earp-Thomas Co.	Clovers Red White Crimson Alsike Mammoth Berseem Sapling	O. K. O. K. O. K. O. K. O. K. O. K. O. K.	41 1 acre	41	2-24-20 5 years 11-2-21
254	Alex. Forbes & Co. Mulford Co.	Soy Beans	O. K.	1,092 ¼ acre	4,368	5-2-21 1 year 3-17-22
255	Alex. Forbes & Co. Earp-Thomas Co.	Cow Peas Garden Peas Garden Beans Soy Beans Lima Beans	None O. K. O. K. Poor Fair	22 15 lbs. seed	89	Not given Not given 3-17-22
256	Alex. Forbes & Co. Mulford Culture	Garden Beans	O. K.	37,800 ¼ acre	151,200	12-24-21 1 year 3-17-22
257	Alex. Forbes & Co. Mulford Culture	Red Clover	Fair	42,640 ¼ acre	170,560	12-9-21 1 year 3-17-22
258	Alex. Forbes & Co. Mulford Culture	Lima Beans	O. K.	27 ¼ acre	108	12-24-21 1 year 3-17-22
259	Alex. Forbes & Co. Mulford Culture	White Clover	O. K.	13	52	12-9-21 1 year 3-17-21
260	Alex. Forbes & Co. Mulford Culture	Garden Peas	O. K.	793 ¼ acre	3,172	12-24-21 1 year 3-17-22
261	Alex. Forbes & Co. Earp-Thomas Co.	Clovers Red White Crimson Alsike Berseem Sapling Mammoth	O. K. O. K. O. K. O. K. O. K. O. K. O. K.	43 1 acre	43	Not given Not given 3-17-22
262	Alex. Forbes & Co. Earp-Thomas Co.	Clovers Red White Crimson Alsike Berseem Sapling Mammoth	O. K. O. K. O. K. O. K. O. K. O. K. O. K.	18 5 lbs. seed	72	Not given Not given 3-20-22

RESULTS OF OFFICIAL ANALYSES—TABLE 61—Continued

Test Number	Town Retail Vendor Wholesale Vendor Commercial Name	Crops and Inoculation		Organisms per package (Millions)	Organisms per acre (Millions)	Date of preparation Guarantee Date of test
	NEWARK					
263	Alex. Forbes & Co.	Alfalfa	O. K.	18	71	Not given
	Earp-Thomas Co.	Swt. Clover	O. K.	6 lbs. seed		Not given 3-20-22
	PATERSON					
264	Hart & Co.	Lima Beans	O. K.	10	10	12-30-21
	Earp-Thomas Co.	Garden Bean	O. K.	1 acre		5 years
		Garden Pea	O. K.			3-30-22
		Cow Pea	None			
		Soy Bean	None			
265	Hart & Co.	Alfalfa	O. K.	6	6	12-30-21
	Earp-Thomas Co.	Swt. Clover	O. K.	20 lb. seed		5 years 3-17-22
		Clovers				
245	Hart & Co.	Red	O. K.	2,340	2,340	3-2-21
	Earp-Thomas Co.	White	O. K.	1 acre		5 years
		Crimson	O. K.			10-19-21
		Alsike	O. K.			
		Berseem	O. K.			
		Mammoth	O. K.			
		Sapling	O. K.			
246	Hart & Co.	Garden Peas	O. K.	1,180		10-19-21
	Earp-Thomas Co.	Soy Beans	None	Garden		5 years
		Garden Beans	O. K.	Size		10-19-21
		Lima Beans	O. K.			
		Cow Peas	None			

TABLE 62

Test Numbers of Cultures to Be Noted for Violations, etc.

Company	Unguaranteed	Poor Inoculation	Number of Samples Tested
	261	255	
	262	264	
Earp-Thomas Co.	241	246	20
	255		
	263		
Stulicof Co.		280	15

TABLE 63

Groups of Plants Inoculated by the Same Specific Organism

1. Red Clover	2. Alfalfa	4. Garden Bean	Acacia
Alsike Clover	Bur Clover	Field Bean	Lima Bean
Crimson Clover	Sweet Clover (Yellow)	Scarlet Runner Bean	6. Vetch
White Clover	Sweet Clover (White)	5. Cow Pea	Garden Pea
Berseem Clover	Fenugreek	Partridge	Canada Field Pea
Mammoth Clover		Velvet Bean	Sweet Pea
Sapling Clover	3. Soja Bean (Soy Bean)	Peanut	Brood Bean
			Lentil

TABLE 64

Number of Quantity of Legume Seeds Commonly Sown per Acre

Crop	Rate of Seeding	Estimated Number of Seeds	Crop	Rate of Seeding	Estimated Number of Seeds
	lbs. per A.			lbs. per A.	
Alfalfa	20	5,100,000	Soy Bean	60	150,000
Sweet Clover	20	4,800,000	Field Bean	80	120,000
Red Clover	12	3,300,000	Cow Pea	70	250,000
Alsike Clover	12	8,400,000	Field Pea	120	265,000
White Clover	10	8,000,000	Peanut	30	36,000
Crimson Clover	12	1,500,000	Velvet Bean	12	18,000
Lespedeza	20	7,400,000	Beggar Weed	10	4,200,000
Spring Vetch	60	540,000			
Winter Vetch	60	960,000			

TABLE 65

Summary of Inoculants Tested

All Crops	Alphano Humus Co.	Earp-Thomas Co.	H. K. Mulford Co.	Western Soil Bacteria Co.	Total	All Crops	Alphano Humus Co.	Earp-Thomas Co.	H. K. Mulford Co.	Western Soil Bacteria Co.	Total
All Crops	2	....	....	....	2	Garden Peas	....	1	2	....	3
Peas, Beans, Sweet Peas	....	3	....	....	3	White Clover	....	....	2	....	2
Clovers: Red, White, Crimson, Alsike, Mammoth, Berseem, Sapling	....	4	....	....	4	Lupine	....	....	....	1	1
Soy Beans	....	....	3	....	3	Garden Beans	....	....	2	1	3
Cow Peas	....	....	....	1	1	Red Clover	....	3	1	1	5
Vetches	....	2	1	1	4	Lima Beans	....	....	1	....	1
Alfalfa	....	1	3	2	6	Alfalfa and Sweet Clover	....	5	....	....	5
						Alsike Clover	....	1	....	....	1
						Total	2	20	15	7	44

TABLE 66

Number of Dealers Registered per County

Atlantic	0	Middlesex	1
Bergen	1	Monmouth	2
Burlington	3	Morris	0
Camden	1	Ocean	1
Cape May	0	Passaic	2
Cumberland	7	Salem	3
Essex	2	Somerset	1
Gloucester	3	Sussex	0
Hunterdon	1	Union	0
Mercer	2	Warren	0

628

Circular No. 703

May 1944 • Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE

Method of Testing Legume Bacteria Cultures and Results of Tests of Commercial Inoculants in 1943

By L. T. LEONARD, *bacteriologist, Division of Soil and Fertilizer Investigations, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

CONTENTS

	Page		Page
Commercial inoculants	1	Method of testing—Continued.	
Regulation of sale	3	Inoculation and planting	5
Method of testing	3	Observations and performance	6
Preparation of subsamples	4	Tests of commercial inoculants in 1943	8
Seed and its treatment	4		

NODULE BACTERIA form an association with the roots of leguminous plants through which nitrogen gas is taken from the air and made available for plant growth. These bacteria are widely distributed in soils, but as there are a number of species, each functioning satisfactorily on certain legumes only, and as strains of the same species vary in their ability to fix nitrogen, the proper nodule bacteria may be lacking in some field soils. They may be isolated from their nodules, tested for efficiency, and propagated to almost any degree under artificial conditions. Commercial laboratories prepare such materials for sale to planters. Whether it is advisable to use artificially prepared cultures of legume bacteria is a matter for local experience to determine.

COMMERCIAL INOCULANTS

At present 11 concerns are engaged in the production of nodule bacteria cultures, or legume inoculants, as they are sometimes called (table 1). For commercial distribution inoculating materials are prepared in "carriers," which are mainly agar (jelly) and moist peat powder. The use of the former within recent years has been declining.

Agar cultures are made by spraying under sterile conditions a suspension of pure nodule bacteria on the surface of hardened sterile special nutrient agar in glass bottles. Usually these bottles are capped with sterilized metal screw caps. The inoculated bottles are incubated at the proper temperature for the organisms they contain, and when good growth is obtained they are packaged and shipped to the merchandiser or consumer. The agar culture must be a pure culture of nodule bacteria, since the growth of contaminants under the extreme artificial conditions may injure the organisms and by appearance may affect the salability of the product.

DEFTS. EX. 21 IDEN.

Defendants Exhibit # 21

629

TABLE 1.—*List of commercial seed and soil inoculants sold in the United States in the fiscal year 1943* [1]

Trade name	Carrier	Manufacturer and distributor	Address
Cal-Rhiz Legume Bacteria	Paste (?)	Nelson Laboratories	Stockton, Calif.
Farmogerm	Agar	Earp-Thomas Laboratories, Inc.	Bloomfield, N. J.
Humogerm	Peat	do	Do.
G. L. F. Legume Inoculant	Charcoal	Cooperative G. L. F. Mills	Ithaca, N. Y.
Hansen's Humus Inoculator	Peat	Hansen Inoculator Co	Urbana, Ill.
Certigerm	do	Eastern States Milling Corp.	Buffalo, N. Y.
Kelly's Humus Inoculator	Peat	Kelly Seed & Hardware Co.	Peoria, Ill.
Kelly's Inoculator	Agar	do	Do.
National Cooperative Humus Inoculator.	Peat	Indiana Farm Bur. Coop. Assn.	Indianapolis, Ind.
Legume-Aid	do	Agricultural Laboratories, Inc.	Columbus, Ohio.
Blue Seal Grow Crop Inoculant.	do	Illinois Farm Bur. Purchasing Agency.	Chicago, Ill.
Sooco Legume Inoculant	do	Smith Agricultural Chemical Co.	Columbus, Ohio.
Legumogen	do	The Legumogen Laboratories, Inc.	Delphi, Ind.
Nitragin	do	The Nitragin Co.	Milwaukee, Wis.
Ned-O-Gen Protected Inoculator.	do	The Albert Dickinson Co.	Chicago, Ill.
Badger Brand Inoculation	do	L. Towles Seed Co., Inc.	Milwaukee, Wis.
Cofer's Hitest Inoculator	do	Cofer Seed Co.	Athens, Ga.
Gold Medal Inoculator	do	Louisville Seed Co.	Louisville, Ky.
Hoffman's Inoculator	do	A. H. Hoffman, Inc.	Landisville, Pa.
Kellogg's Rainbo Inoculator	do	Kellogg Seed Co.	Milwaukee, Wis.
M-Inoculator	do	Ed. F. Mangelsdorf & Bro., Inc.	St. Louis, Mo.
May-Bell Inoculator	do	Rose Seed Co.	Louisville, Ky.
Ohio Farmers' Seed Inoculation.	do	Ohio Farmers' Grain & Supply Co.	Fostoria, Ohio.
Red Bird Inoculator	do	Lewis Seed Co.	Louisville, Ky.
Sioux Brand Inoculator	do	Sioux City Seed Co.	Sioux City, Iowa.
Trinity Brand Inoculator	do	Belt Seed Co.	Baltimore, Md.
Wood's Seed Inoculation	do	T. W. Wood & Sons	Richmond, Va.
Superyield Culture	Agar	Strasburger & Siegel	Baltimore, Md.
Uni-Culture	Peat	Kalo Inoculant Co.	Quincy, Ill.
American Tubercle Germ	do	American Field Seed Co.	Chicago, Ill.
Berry's Superior Nodule Germ.	do	Berry Seed Co.	Clarinda, Iowa.
Blue Ribbon Inoculation	do	Allied Seed Co.	Fort Wayne, Ind.
Cornell Keystone Inoculation	do	Cornell Seed Co.	St. Louis, Mo.
Farm Master Nitrogen-Fixing Inoculant.	do	Sears, Roebuck & Co.	Chicago, Ill.
Kalo Inoculation	do	Kalo Inoculant Co.	Quincy, Ill.
Perfection Brand Legume Inoculant.	do	Geo. P. Bemser & Son	Des Moines, Iowa.
Southern States Quality Inoculation.	do	Southern States Cooperative	Richmond, Va.
Seedaid Inoculant	do	Sunfield Seed Co.	Chicago, Ill.
Urbana Culture	Agar	The Urbana Laboratories	Urbana, Ill.
Urbana Humus Inoculator	Peat	do	Do.

[1] Indented trade names indicate material originating in same laboratory as that of the unindented name above; indented names of firms following those of manufacturers denote distributors of subbrand inoculants.

Peat-powder inoculants, on the other hand, are usually prepared commercially by developing a heavy suspension of pure nodule bacteria in aerated liquid nutrients in protected tanks. When at the right stage of growth, the suspension is withdrawn and mixed thoroughly with neutralized peat powder. Further processing may include (1) curing (allowing to stand in a bin or tub for a few days), (2) additional mixing to obtain particle uniformity, and (3) packaging. It is then ready for the retail trade. Prepared in this manner inoculants are not pure cultures, but the presence of other organisms does not seem to affect their efficiency, and they are not sufficiently in evidence as a rule to affect the salability of the product.

The most important ingredient in an inoculant is its content of efficient living organisms. Under the conditions of transportation and storage these organisms may be gradually killed. The useful

630

period, therefore, is necessarily limited. This is usually less than a year, and the end of such period is ordinarily shown on the label of the package.

REGULATION OF SALE

For the protection of the planter against products of incompetents and from depreciated material some regulation of the industry is desirable. In addition to certain regulations by the United States Department of Agriculture, the following State institutions are charged with the regulation of the sale of inoculants within their State borders: Indiana Agricultural Experiment Station, at La Fayette; Kansas State Board of Agriculture, at Topeka; University of Maryland, at College Park; New Jersey Agricultural Experiment Station, at New Brunswick; Feed and Fertilizer Control Office, State College, N. Mex.; New York Department of Agriculture and Markets, at Albany; Ohio Department of Agriculture, at Columbus; and Wisconsin Department of Agriculture and Markets, at Madison. Some of these do not make tests of samples.

Where testing of samples is done, it is customary to collect each season sufficient material from each producer to give a satisfactory test of the product. Inoculants are sold by seed and hardware stores, grain elevators, mills, and farm agencies.

METHOD OF TESTING

The function of cultures of nodule bacteria is to produce stimulatory effects by furnishing nitrogen to the legumes to which they are applied. Under practical conditions commercial inoculants are used in the field, and it would seem advisable to test them under similar conditions. Field testing, however, is unsatisfactory on account of several factors, among which may be mentioned the almost universal presence of some species of nodule bacteria and varying climatic and soil conditions, some of which cannot be controlled. In view of these circumstances the greenhouse offers the most prompt, effective, and economical means of testing legume bacteria of the various groups under fairly well-controlled conditions of moisture, light, and temperature.

In greenhouse work of this kind various types of containers and apparatus for growing and watering plants have been employed. Sand is the material usually used to support root growth. A self-irrigating assembly recently has been devised for use in testing numerous samples in limited greenhouse space.[1] Briefly, as modified since its description was published, it consists of a 32-ounce screw-cap-finish bottle from which the bottom has been cut, as a container for a mixture of sand, dolomitic limestone, superphosphate, and potassium sulfate. The mouth end of the bottle is fitted with a plastic cap that has a hole in the center small enough to retain the sand. This end rests on the shoulders of a wide-mouthed pint cream

[1] LEONARD, L. T. A SIMPLE ASSEMBLY FOR USE IN TESTING CULTURES OF RHIZOBIA. Jour. Bact. 45: 523-525, illus. 1943.

631

jar holding an acid nutrient solution containing zinc, copper, manganese, iron, and boron salts in very minute quantities. As prepared, the neck of the bottle with cap extends nearly to the bottom of the jar.

After the sand has been completely irrigated, holes are punched in its surface to receive seedlings. The cut end of the bottle is then covered with a Petri dish lid and the whole assembly subjected to steam sterilization in an autoclave. The sand is kept moist by the nutrient solution, which is drawn up by capillarity. The solution is sufficiently acid (pH 2.0) to preclude the survival of any common rhizobia that might drop into the jar when the solution is replenished. Upon reaching the sand the acid solution is neutralized and when carried farther up it becomes available as a nutrient for plants.

Preparation of Subsamples

Before testing moist peat materials, samples are weighed to obtain the net content of carrier in the package. The number of pounds the sample will treat is multiplied by 16, and the net weight of the sample in grams is divided by the number obtained to give the quantity of material in grams necessary for 1 ounce of seed. This is usually very small. Instead of subjecting the inoculant to the possibility of contamination in the process of direct weighing, an approximation of the quantity may be obtained by the use of disinfected, calibrated, narrow glass cylinders, from which the peat powder may be expelled by a disinfected piston of slightly smaller diameter than that of the cylinder. Cylinders and pistons are disinfected by 150° C. dry heat for 1 hour and are allowed to cool before using.

A flame is passed over the lid end before opening samples in cans with removable lids. Sealed cartons and crimped-end cans without a removable lid are opened by cutting with a disinfected knife, into the middle of the side of the container, 3 sides of a rectangular hole, the fourth side acting as a hinge. The carrier is poured from this opening into a properly labeled sterile Petri dish. Labeled sterile vials for subsamples from each package are arranged in holes on a wooden board. A glass cylinder with a piston set at the proper calibration point is tamped in the peat powder until it is filled to the end of the piston. Then, with the aid of an assistant, the subsample is discharged into a sterile vial. Usually five subsamples are taken, but occasionally more are desirable, especially from multiple-group cultures. Lids are replaced or holes are closed with masking tape as soon as possible after part of the contents is removed from the cans.

Agar cultures are not subsampled in this manner. They are prepared according to directions at the time of planting, and subsampling is done by means of sterile pipettes. The common method of preparing agar cultures for use is to add water and shake thoroughly to obtain a homogenized suspension of the nodule bacteria in the bottle.

Seed and its Treatment

Seed of the highest quality obtainable should be used in this work. It should be of uniform size, high in germinating ability, scarified when necessary, and free of debris and of defective, deformed, and broken seeds.

Since commercial legume bacteria cultures are customarily prepared for groups of legumes, each named on the package label, it is

necessary to have on hand a small stock of the various kinds of legume seeds. It is not always possible to test samples on all the species or varieties of legumes for which they are intended, but it is desirable to try them on some of the more common legumes mentioned. Legume seeds ordinarily used in testing cultures are listed below.

Group designation of bacterial sample:	*Plants upon which tests are made*
Alfalfa	Alfalfa and white sweetclover.
Alyce clover	Alyce clover.
Beans	Navy and green beans (Stringless Green Pod and dwarf varieties).
Clover	Crimson, red, and white clovers.
Cowpeas	Cowpea, crotalaria, kudzu, lima bean, and peanut.
Lespedeza	Annual (Kobe, Korean) and perennial species.
Lupine	Blue lupine and other species.
Soybeans	Biloxi, Laredo, Mammoth Yellow, Tokyo, Virginia, and Wilson varieties.
Vetch	Hairy vetch, garden pea (Alaska, Nott Excelsior), and Austrian Winter pea.

Seeds are first washed in sterilized weak peat water to remove clinging dirt particles, then agitated for 5 minutes in a 0.2 percent solution of mercuric chloride. After the disinfecting solution is thoroughly drained away, sterile peat water is used to remove soluble traces of the mercury salt, following which the mouth of the seed container (usually a 16-ounce, screw-capped, wide-mouthed bottle) is covered with a small blanket of sterile absorbent cotton and inverted so as to throw the seeds on the cotton and thereby dry them by draining.

As soon as the disinfected seeds pour easily they are ready to use. Petri dishes containing 0.6 percent sterile agar are prepared, and when hardened the seeds are sown on the surface for germination. Sometimes with large seeds it is desirable to compensate for excessive imbibition by adding sterile peat water. A good temperature for germinating most seed is 70° F.

The number of seedlings that can be planted in an assembly is determined by the growth habits of the resulting plant. Alfalfa, white sweetclover, red clover, crimson clover, and lespedeza may be planted six in a jar; cowpeas, soybeans, crotalaria, mung beans, and lima beans, three; and peanuts, one per jar. If it is desirable to conserve space, two of each of three species of the smaller seedlings may be planted in a jar, or, in the case of soybeans, two of each of two varieties.

Inoculation and Planting

Sterilized planting assemblies, germinated seeds, and subsamples of inoculating material are necessary at the start of the process of inoculation. Sterile Petri dishes and means of disinfecting the instruments (boiling water) should be at hand. A predetermined quantity of sterile water is added to each subsample, usually 20, in a series, and the vials shaken vigorously. Seedlings are placed in sterile Petri dishes in sufficient number to prepare at least 3 replicates of all treatments and 9 of no treatments. The series may also include 9 controls

633

inoculated with a known pure culture. The suspended samples are added to the seedlings and the Petri dish agitated to make good contact between seedlings and inoculum.

This method of treatment does not exactly conform to the directions given. The seedlings however, are bathed in a suspension of inoculating material prepared in quantities proportional to those prescribed, and therefore they receive approximately the same quantity as would ungerminated seeds plus those that adhere to the small rootlets.

The seedlings are transferred to previously made holes in the sand by using disinfected forceps. These plantings are usually made in a circle in the center of the bottle, the distance from the side depending on the kind; they are covered by depressing the sand in the middle by means of a ¾-inch rounded metal tamper. A half inch of sterile gravel may then be added to prevent undue evaporation.

Assemblies are labeled on the bottle as to legume, treatment, and date of planting. Replicated treatments consisting of three assemblies are kept together in the greenhouse. Control sets of three are interspersed with the treated sets. Each assembly is placed on a number on the greenhouse bench. Under this number in a notebook the treatments and dates of planting are recorded on a form sheet upon which observations also are placed later. The number of the space used is also placed on the nutrient reservoir to prevent errors when the assemblies are rearranged or removed for observation.

In the greenhouse, control of insects and dust and isolation from ordinary greenhouse operations are necessary. As soon as assemblies are placed, lids may be removed to give better light, aeration, and physical conditions for growth, although the removal presents possibilities for contamination by foreign rhizobia. Since much better growth is obtained in the absence of the lids, however, it is preferable to dispense with them and maintain strict sanitation in the greenhouse.

Plants are usually allowed to grow for about 45 days, unless early maturity or a desire for information requires their earlier removal or it is apparent that a longer period would be advisable.

For some species, as cowpeas, peanuts, or soybeans, in short-day seasons it is desirable to furnish additional light. This is done by using electric bulbs with reflectors, beginning at sundown and continuing 4 or 5 hours into the night. Alfalfa, clovers, and vetch produce satisfactory results from the light coming through the greenhouse glass during the winter season.

In the case of vining or high-growing plants, supports are necessary to prevent falling or intertwining. This is done by means of disinfected hardware-cloth cylinders that will fit snugly around the sand bottles.

Observations and Performance

The main points to consider for effect of inoculating material are the differences between treated and control plants in nitrogen content, dry matter, color, size of plants, and nodule formation. In special cases, nitrogen analysis may be desirable, but for the ordinary estimation of bacterial stimulation color is a good index of nitrogen fixation or lack of it. Color may be observed more satisfactorily while the plants are in the greenhouse.

Observations on color and height are preferably made before the

plants are disturbed by removal from bottles. After roots are freed from sand by washing in water they are examined in a bottom-illuminated glass water bath, originally described by Marsh and Leonard [2] and later modified by Marsh to give side light. By means of this bath roots floating in water are easily measured and estimates made of nodule numbers and their location.

If observations on color show that plants from treated seeds are dark green and the corresponding control plants are light or yellowish green, it is a positive indication that organisms and the plant through symbiosis have produced satisfactory results.

TABLE 2.—*Summary of results of greenhouse tests on samples of legume bacteria cultures of commercial origin in the fiscal year 1943*

[U=unsatisfactory; S=satisfactory]

Trade name	Alfalfa		Clover		Cowpea		Lespedeza		Soybeans		Beans		Vetch		Total		Sources total [1]	
	U	S	U	S	U	S	U	S	U	S	U	S	U	S	U	S	U	S
Cal-Rhiz Legume Bacteria	0	5	0	3	0	2			0	2	0	2	0	10	0	24	0	24
Farmogerm	4	0	2	2									1	3	7	5		
Humogerm	2	0	2	0									0	2	4	2	11	7
G. L. F. Legume Inoculant	2	2	4	0									3	1	9	3	9	3
Hansen's Humus Inoculator	0	2	4	2									0	6	4	10		
Certigerm	0	3	0	3			3	0	1	2			0	3	4	11		
Kelly's Humus Inoculator	0	2													0	2		
Kelly's Inoculator			0	2											0	2		
National Cooperative Humus Inoculator	0	2	0	2			2	0	0	2					2	6	10	31
Legume-Aid	0	2	0	2	0	2	0	2	0	6	1	4	0	11	1	29		
Blue Seal Grow Crop Inoculant	0	7	0	7					0	1					0	15		
Sacco Legume Inoculant	0	2													0	2	1	46
Legumogen	0	4	0	4					0	2					0	10	0	10
Nitragin	0	5	0	6	0	2	0	6	0	4	0	4	2	11	2	39	2	39
Nod-O-Gen Pretested Inoculator	0	6	0	6	0	2			0	5	0	5	0	10	0	25		
Badger Brand Inoculation	0	4	0	2											0	6		
Cofer's Hitest Inoculator	0	2	0	2	0	3	0	3	0	3	0	3	0	2	0	16		
Gold Medal Inoculator	0	2	0	2	0	3	0	3	0	3			0	2	0	15		
Hoffman's Inoculator	0	2	0	2	0	3	0	3	0	3			0	2	0	15		
Kellogg's Rainbo Inoculator	0	2	0	2					0	3			0	2	0	9		
M-Inoculator	0	2	0	3	0	2	0	3	0	2			0	2	0	14		
May-Bell Inoculator	0	4	0	4	0	3	0	3	0	3			0	2	0	19		
Ohio Farmers' Seed Inoculation	0	2	2	0											2	2		
Red Bird Inoculator	0	2	0	2									0	2	0	6		
Sioux Brand Inoculator	0	2	0	2											0	4		
Trinity Brand Inoculator	0	3	0	2			0	6	0	2			0	2	0	15		
Wood's Seed Inoculation	0	2	0	2	0	5	0	3	0	3	0	3	0	5	0	23	2	181
Superyield Culture									0	6	0	4	1	15	1	25	1	25
Uni-Culture	0	4	0	4					0	4					0	12		
American Tubercle Germ	1	3	0	4	0	3	0	3	0	3					1	16		
Berry's Superior Nodule Germ	0	2	0	4	0	3	0	3	0	1			0	3	0	18		
Blue Ribbon Inoculation	3	0							0	6					3	6		
Cornell Keystone Inoculation	0	4	0	4	0	6	0	3	0	3			0	2	0	22		
Farm Master Nitrogen-Fixing Inoculant	0	2	2	0					0	1					2	3		
Kalo Inoculation									0	1			0	4	0	5		
Perfection Brand Legume Inoculant	0	3	0	3			3	0	2	4					5	10		
Southern States Quality Inoculation	0	4	0	4											0	8		
Sunfield Inoculant	0	4	0	4											0	8	11	106
Urbana Culture	0	2	0	2	5	0	0	6	0	6	0	6	0	2	5	24		
Urbana Humus Inoculator	0	2	0	4									0	2	0	8	5	32
Total	12	101	16	97	5	41	8	47	3	81	1	31	7	106	52	504		

[1] This column gives test results with products of individual manufacturers without particular reference to trade names.

[2] MARSH, F. W., and LEONARD, L. T. AN APPARATUS FOR THE SUPERFICIAL EXAMINATION OF ROOTS AND NODULES. Soil Sci. 26: 403-404, illus. 1928.

635

If upon root examination nodules are found to be uniformly present on the dark-green plants from treated seeds and none or only a few on the control-plant roots, there is no doubt as to the effectiveness of the culture.

If plants are yellowish or not a normal green and no nodules are formed, it is evident that the treatment did not contain the proper organisms and is therefore unsatisfactory.

If foliage is yellow or not a normal green and nodules are observed uniformly on the roots, it shows that the culture is not adapted to the host and consequently is unsatisfactory. This condition, however, is found only occasionally.

TESTS OF COMMERCIAL INOCULANTS IN 1943

Using the method here described, the Bureau of Plant Industry, Soils, and Agricultural Engineering during the year ended June 30, 1943, tested numerous samples of inoculating materials seasonally collected in the open market from various parts of the country. This work was done in accordance with an act of Congress making appropriations for soil and fertilizer investigations "* * * including the testing of cultures procured in the open market for inoculating legumes, other crops, or soil * * * *." The act provides also for publication of the results of the tests together with the names of the manufacturers "* * * if any such samples are found to be impure, nonviable, or misbranded * * *." Results of the 1943 tests are thus summarized in table 2, reference to table 1 showing the names of producers. The manufacturers of samples found to be unsatisfactory were notified of the results, so that steps could be taken to improve the product for the 1944 season.

U. S. GOVERNMENT PRINTING OFFICE: 1944

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NITROGEN from the AIR

CONVERTED INTO

FOOD for PLANTS

BY

FERGUSON'S NITROGEN BACTERIA

"Living Nitrate Factories for Field and Garden."

A COMPOSITE CULTURE

One bottle available for all legumes.

Four ounces properly applied to the seed for an re of ground will put as much nitrates into the il as can be obtained in **two tons** of high grade mmercial fertilizer, with less labor and less pense.

THIS MEANS

Profitable crops on poor or sandy soils
Restoration of worn out lands
Increased crops on good lands

HOMEWOOD NITROGEN CO.

Laboratories, 117 West Main Street

Richmond, Virginia

usiness Office, 51 Liberty Street, New York City

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HISTORY

For centuries the farmers of the world have known that crops have been larger when grown on a field that had previously been planted to clover or other legumes. Why this was so was not understood, but a German scientist and chemist, Professor Heilriegel, of the University of Frankfort, about the year 1860, discovered that the nodules on the roots of these legumes contained active colonies of bacteria. After long experiments he was able to isolate these bacteria. The scientific fact of the utility of the bacteria in increasing the growth of the legumes was thus observed and established, but no efficient method was discovered for their commercial utilization. These researches were continued by the scientists of Germany and many years later were taken up by the experts of the Agricultural Department at Washington and also by the experts of some of the agricultural stations of the various states. Prominent among these was Dr. Meade Ferguson, State Bacteriologist of the Commonwealth of Virginia. For about ten years Dr. Ferguson continued his tests and experiments, putting up thousands of packages in different forms, sending them to the farmers and official stations for practical and field tests throughout a large territory. In this way a large amount of data of the greatest value was obtained, showing the increase of the crop, the enrichment of the soil, and the best methods and means of obtaining the same. So successful were these tests and demonstrations that today Dr. Ferguson has justly earned the position as one of the leading scientists and bacteriologists of the world. The results of these discoveries have been made available to the public through the products of the laboratories of the Homewood Nitrogen Company at Richmond, Virginia.

WHAT ARE NITROGEN-FIXING BACTERIA?

Nitrogen Fixing Bacteria are small living organisms having the power to take nitrogen from the air, convert it and fix it in a form available for plant life. In this way they supply to the soil the nitrates which are the most expensive and valuable of all fertilizers. The bacteria not only feed the plant, acting as their host, but also store up surplus supplies of nitrogen in the form of nodules upon the roots of such host plant.

These bacteria thrive on certain leguminous plants, of which there are thirty-seven varieties. The principal of these are alfalfa, clovers, beans, peas, vetches, lupines, soy beans, etc. The bacteria are not recommended as being directly applicable to the cereals, such as wheat, oats, corn, barley, etc., although such crops can be directly benefited by planting with them some inoculated legume seed such as field peas, the leguminous plant in such case furnishing the nitrates for the cereals as well as for itself. They also benefit the cereals indirectly when such crops are planted on soils that have previously grown inoculated legumes.

DR. FERGUSON'S COMPOSITE CULTURE

Dr. Meade Ferguson, State Bacteriologist of the Commonwealth of Virginia, has discovered a method by which he has achieved most remarkable and valuable results in the production of a composite culture which is available for any leguminous plants. Through his work it is now no longer necessary to have a separate inoculation for alfalfa, a separate inoculation for clover, a separate bacteria for vetch, a separate bacteria for beans, a separate bacteria for peas, etc., throughout the entire list. Dr. Ferguson's composite culture can be used with equal effectiveness upon any or all of the legumes.

NITROGEN AND ITS DEPOSIT

Nitrogen is the most important and most expe
of the essential constituents for a good agricu
soil. It is rapidly depleted by the growing and
moval of grains and many other crops. This re
in the impoverishment of the soil, the diminution
the crops, and the steady depreciation of farms. T
process has been exemplified in the steady exhau
of the soil of the abandoned farms of New Engla
A bankrupted soil has meant deserted comm
This process is now being repeated in the great
ing region of our middle, southern and western st
Nitrogen, however, in the form of nitrates can be
back in the soil from the atmosphere itself through
presence and activity of these nitrogen fixing bacte
Every acre of ground is covered with atmosphere c
taining about 77.77% by weight of pure nitrogen
the equivalent of about 1,680 pounds of nitrogen
the square foot, or nearly 40,000 tons of nitrogen
the acre,—a simply inexhaustible supply when
available for plant life through the activity of
bacteria. Practically all soils, even those that h
been most exhausted, can be rehabilitated in this w
If land has turned sour it must first be limed so as
neutralize its acid condition before the bacteria c
do their work.

OTHER FERTILIZERS—COST AND INEFFICIENCY

The means generally adopted to restore nitro
to depleted soils are:

(a) The application of barnyard manure, s
other organic matter about the farm. As this ma
terial contains only about one-third of one per ce
of nitrogen, the supply at hand is hardly ever ade
to return to the soil the amount of nitrogen, remo

cropping. Furthermore, such fertilizers often con- other elements that are a positive detriment to farmer and involve much additional work.

(b) Commercial fertilizers are manufactured and but their supply is limited and their cost is high. igh-grade commercial fertilizer, containing only 4% nitrates, sells upon the market for over $40 per . A ton of such fertilizer puts into the soil only out 80 pounds of nitrates against a total enrichment ctimes found of 850 pounds of nitrates, deposited one acre of ground through the use of one four- ce bottle of Ferguson's Nitrogen Fixing Bacteria, n properly applied through inoculated seed.

(c) The contemplated process of making nitrates the electric current does not offer much relief, be- se the price of nitrates even when manufactured ll not be much if any lower. This makes it un- ractive to the practical farmer.

COMPARATIVE EFFICIENCY OF FERGUSON'S COMPOSITE BACTERIA WITH OTHER BACTERIA

Ferguson's Composite Nitrogen Fixing Bacteria is de according to a new process of culture. In order show the comparative value of Ferguson's with ers, tests were made by E. B. Fred, Bacteriologist the Virginia Experimental Station, under the ited States Department of Agriculture.

In order to test the value of different inoculating ro-cultures now employed extensively for artificial culation, samples were secured and bacterial counts de. All nitro-cultures were diluted as directions ed for, and one pint samples were set aside from ch the counts were made. The following table es the number of bacteria per c.c. in the four cul- es examined:

	Ferguson's Composite Bacteria	Old Process	Agr. Dep't Washington	Farmogerm
Red Clover	180,000	51,600	3,400	50
Alfalfa	205,500	41,000	5,000	38
Cow Pea	220 000	51,600	7,000	42
Soy Bean	85,000	53,000	2,700	36
Crim. Clover	250,000	53,000	6,000	55

Old Process Cultures were those originally prepared by Dr. Meade Ferguson, formerly of Virginia Experimental Station.

Agricultural Department, Washington, cultures, were prepared by the Agricultural Department of the United States.

Farmogerm were cultures prepared by the Earp-Thomas Co. of New Jersey.

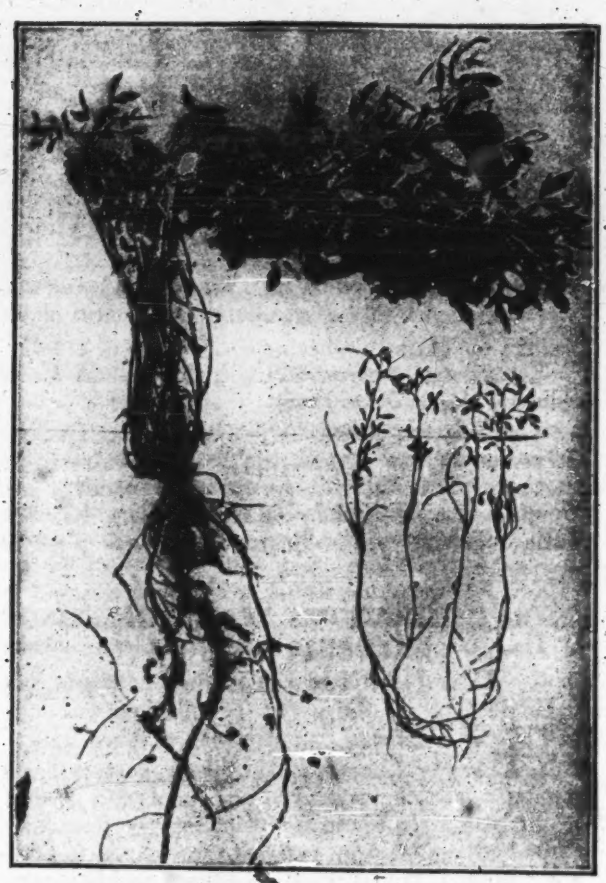
The Ferguson Composite Nitrogen Fixing Bacteria is unique in that it possesses features unknown to any other formula, viz., its *composite nature*. Dr. Ferguson has solved the problem of making Nitrogen Fixing Bacteria applicable to any legume plant in any soil.

WHAT FERGUSON'S NITROGEN-FIXING BACTERIA WILL DO

1. These bacteria furnish the best and most valuable fertilizer in the world, in unlimited quantities and at only a nominal cost of money or labor.

2. They take nitrogen from the air, convert it into nitrates available for plant food, and then give it to the plant. In return the plant supplies them with carbo-hydrates, thereby enabling the bacteria to grow and reproduce themselves at an almost incredible rate.

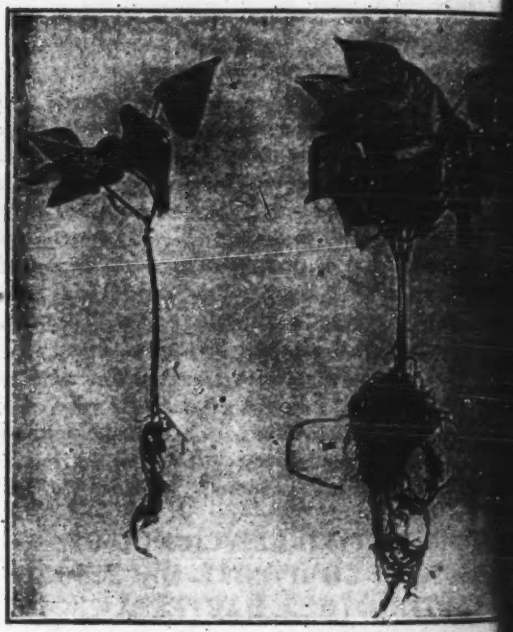
3. **They increase crops,** under ordinary conditions from 25% to 60%, with no extra work. They make possible profitable crops on absolutely barren soil, such as sea sand or even coal ashes. They also improve the crops on good farm land.



ALFALFA PLANTS—Planted at the same time and in the same soil and under the same conditions.

Those on the left were inoculated with Ferguson's Nitrogen-Fixing Bacteria. Those on the right were not inoculated. Notice nodules on the inoculated plant.

(This illustration is an exact reproduction from the official government bulletin, No. 159, of the Virginia Agricultural Experiment Station.)



SNAP BEANS—Grown in coal ashes.

The one on the right was inoculated with Ferguson's [illegible] Fixing Bacteria; that on the left was not inoculated. Notice [illegible] on inoculated plant.

(This illustration is an exact reproduction from the official [illegible] ment bulletin, No. 154, of the Virginia Agricultural [illegible] Station.)

4. They store up on the roots of such [illegible] the excess nitrates which the plant does not use. [illegible] is done in the form of nodules, varying in size [illegible] mere speck to about a half inch in diameter. [illegible] reports show this reserve supply of nitrates that [illegible] in the ground has been in some tested cases [illegible] 850 pounds per acre, or more nitrates than are [illegible] tained in several tons of the average commercial [illegible] tilizer.

. **They gather moisture** from the air at the e time that they gather nitrogen, and also make it ilable for the future use of the plant. This enables oculated field to withstand some droughts or dry ns that would otherwise destroy the crop.

. They work night and day *making money* for the ner.

WHAT THEY WILL NOT DO

. They will not live if exposed to strong sunlight extremes of heat or cold. After they are once ted and take up their work in the ground they live through a cold winter or hot and dry summer out injury.

. They will not do well in a sour soil. If the l is sour it should be well limed according to its ition, with from 500 lbs. to two tons of ground rbonate of lime or its equivalent, per acre, and then inoculated seed will produce large increase. e our booklet on "Sour Soils and How to Test m."

. They will not do the plowing or cultivating of ld when the farmer has been unable or too lazy to perly prepare the soil for any crop, but if given the ortunity they will put the field in better condition succeeding crops.

DIRECTIONS FOR USING

t. Do not open the bottle of bacteria before you ready to use it. If you do, it is liable to spoil. en everything is ready, uncork the bottle and place the sugar contained in the small envelope supplied the bacteria, and shake thoroughly until dissolved. sugar supplies a food for the bacteria and makes active until such time as the seed germinates.

ld. Then fill the bottle with water. The water ly acts as a carrier, to spread the bacteria to all eeds. The amount of water required varies somet with the different varieties of seed. The small h, alfalfa and all the clovers, do not readily take up

moisture, and so a small quantity of water is sufficient. Vetch, peas and beans, having much greater bulk, require a larger amount of water. Therefore when inoculating vetch, peas or beans fill the bottle a second time with water and add to the first mixture.

3rd. Then sprinkle by hand this liquid upon the seed, which has been heaped upon a cleanfloor or placed in a clean vessel, until every seed is slightly moist. It is essential that every seed should be slightly moist but not wet. If too much water is used then the seeds can be quickly made dry enough to sow by scattering or mixing a little dry sand or fine sifted coal ashes through the mass.

4th. As soon as the seed is dry, sow at once and harrow in at once. Avoid strong sunlight and do your sowing early in the morning or late in the evening, or on a cloudy or rainy day. Strong *sunlight kills* every kind of bacteria.

CAUTION

Do not uncork the bottle until you are ready to immediately inoculate the seed with it. Exposure to the air is almost certain to contaminate it with other bacteria.

Do not mix this bacteria in unclean or rusted vessels or with hot water or with ice water. *Remember* that it is possible to kill the bacteria by excess heat or excess cold, or with certain acids, such as are found in sour soil.

Do not apply the bacteria to the seed in the *sunlight* or expose to the sunlight to dry after mixing. *Remember* that strong sunlight kills every form of bacteria. The best results are obtained when planting is done in the early morning or late afternoon or on cloudy days.

We do not advise transference of soil, for in a large percentage of cases such transfers bring detrimental bacteria and fungus growths that are injurious to the crop, and especially to the future crops in subsequent years.

LIFE OF BACTERIA

All the bacteria sold by the Homewood Nitrogen Company is guaranteed as viable for a limited period after shipment, the date of such guarantee being stamped on each package. Dr. Ferguson's experience has shown, however, that large quantities of his bacteria have been kept alive and in an active state for two years and over without deteriorating, making Dr. Ferguson's composite nitrogen fixing bacteria in this respect incomparably superior to any other on the market. Official investigations by the Geneva Experimental Station of the State of New York showed that in all the other commercial nitro-cultures which were examined by them, practically all were devoid of living bacteria after the first few weeks. Such cultures would be not only useless but in many instances detrimental.

BACTERIA INCREASE CROPS

Careful tests show that certain leguminous crops are increased from 25% to 60% through the use of nitrogen fixing bacteria. This involves practically no additional labor, as the entire process of preparing the seed for an acre of ground can be done within less than an hour's time and with no additional cost for machinery or equipment. The use of Ferguson's Composite Fixing Bacteria is particularly attractive to the farmer, as it not only shows a great saving in initial cost but a great saving of labor necessary in the spreading of ordinary commercial fertilizers. The simplicity of the process of inoculating the seed will be seen by reading the directions in this booklet.

BACTERIA HARMLESS

Ferguson's Culture of Nitrogen Fixing Bacteria is absolutely harmless. It cannot hurt the hands of any one handling it, nor does it cause disease in any way. It is absolutely safe.

TESTIMONIALS FROM PRACTICAL FARMERS

(Copy of letter of George Carragan, President of the First National Bank of Bayonne, New Jersey)

RESULTS WONDERFUL.—About three years ago I had occasion to use some of Ferguson's Composite Nitrogen Fixing Bacteria on my farm at Somerville, New Jersey. At that time I used it on several acres of alfalfa and on a field of soy beans. I also used on my meadow land where inoculated clover seed was planted with timothy. The results of the inoculation were indeed satisfactory, and wonderful. The alfalfa has grown during the time since the planting, giving four cuttings each year, which considered very remarkable by the farmers about Somerville, Jersey. The crop of hay on the meadow lands was much larger than it had been in previous years.

The farm now not only produces an abundance of hay for the feeding of the stock, but I have sold several tons each year. I have taken great pleasure in recommending Ferguson's method of fertilization and believe that it will be of great value to farmers when properly applied.

October 25, 1912. Very cordially yours,

Geo. Carragan

(Copy of letter from W. R. Comfort, President Realty Co., Director Dairymen's Mfg. Co., Broadway Trust Co., Etc., New York City)

SUCCESS WITH ALFALFA.—For three years I have been trying to secure a stand of alfalfa on some land of poor quality in the edge of the Everglades near Miami, Fla., but have been unable to do so until this year when I used the alfalfa seed inoculated with Ferguson's Nitrogen Fixing Bacteria prepared by your Company. I am very pleased to tell you that this has resulted in a very wonderful growth and satisfactory stand of alfalfa. I am more than pleased at the results and believe that the use of Ferguson's Nitrogen Fixing Bacteria will be of great value to the farmer when properly used.

Very truly yours,

W. R. Comfort

(Copy of letter of Mr. C. H. Griffing, formerly Manager of the Woodland Department of the International Paper Co.)

RESULTS OF LONG SERIES OF TESTS.—For several months experiments have been conducted under my personal supervision of the effect of inoculating seeds with Ferguson's Nitrogen Fixing Bacteria. I have seen seeds of alfalfa

...mson clover, white clover, alsike clover, fenugreek, string ...ans, lima beans, soy beans, field peas, garden peas, sweet ...ea, and other legumes, treated with this bacteria and planted ...different kinds of soil, varying from good rich soil to ...sal ashes and ocean sand. Uninoculated seeds were planted ...separate pots, under identically the same conditions of ...ed, soil and moisture. These tests were conducted with ...reat care to find out just what effect moistening with Fer...son's bacteria would have. The results showed a sub...antial increase where the inoculation was used, and in some ...stances a very remarkable growth.

I also examined a field where a test was made upon a ...ge scale. In California twenty-one acres were planted ...th fenugreek inoculated with Ferguson's bacteria and five ...res without inoculation. The ground where this test was ...ade was unusually rich so that less difference would be ...pected. The growth above ground, however, showed a ...bstantial increase in favor of the inoculated seed, while ...e roots and growth below ground showed at least twice ...e growth and number of nodules compared with that of ...e uninoculated. This increased root and nodule growth ...as undoubtedly responsible for and the cause of the superior ...ndition of the plants above ground. The soil was also ...doubtless permanently enriched by the nitrates deposited in ...e nodules.

From my investigation and experience I am convinced that ...erguson's Nitrogen Fixing Bacteria are of very great prac...ical value to the farmers and land owners when properly ...plied.

Very truly yours,

C. H. GRIFFING.

ST WITH COTTON.—In the Spring of 1910, at the request ...f Mr. Hurst, who has a large cotton plantation at Glover, ...Soto County, Mississippi, I went from New York to his ...antation to make and superintend a test of Ferguson's ...itrogen Fixing Bacteria in connection with the growth of ...tton plants. The test was made on his plantation of about ...ree hundred acres then in cotton plants, selecting there...om two acres of average conditions for the purpose. The ...il was a dark, rich loam, Mississippi bottom land. On it ...d been grown cotton for many years, practically without ...terruption. In recent years a large amount of fertilizer ...d been used, the cost of the fertilizer being reported at ...er $30 per acre per year. With this fertilization the land ...d been producing about two bales of cotton to the acre.

At the time of starting the test, in April, the cotton ...nts on the plantation were about six inches in height.

On the two acres selected Canadian field peas were drilled into the ground about eight inches distant from the cotton plants. These field peas had first been inoculated with Ferguson's Nitrogen Fixing Bacteria, the process of inoculating taking only a few minutes. The field peas made a rapid and strong growth, benefitting the cotton plants, so that they showed a noticeably increased growth over the surrounding cotton plants in a short time. The results obtained on the two acres, where the inoculated peas had been planted, showed a marked increase in the crop, making a gain of about half a bale of cotton to each acre or the equivalent of a twenty-five per cent increase over the crop on adjacent acres.

In obtaining there results the cost of the use of Ferguson's Nitrogen Fixing Bacteria and of the field peas (of which about 20 pounds were used to the acre) was only a small fraction of the cost of other fertilizers and the labor in drilling the field peas was much less than spreading the fertilizer for the same ground.

I believe that a substantial increase in the cotton crop in many sections of the country can be economically and profitably secured through the proper use of Ferguson's Nitrogen Fixing Bacteria.

FRANK M. HEMPHILL, Newark.

(LETTER OF J. M. COBB, ATAHSON, N. C.)

INCREASE FIVE FOLD.—Your favor received asking how I liked your nitrogen fixing bacteria. I must say to give my honest opinion that it would increase our average yield five-fold if it is properly used. It gives promise of doing more for me. Your directions were closely followed and experiment plot made on the road showing travellers the benefit to be derived from it.

J. M. COBB.

(LETTER OF L. A. LEWIS, OF THE ALBRO J. NEWTON CO., BROOKLYN)

RESULTS OF A POT TEST.—I got a test bottle of Ferguson's nitrofying bacteria some time ago as I wished to make a test on alfalfa seed that I had bought for this year's sowing. I got two plant jars of the same capacity, filled the two with the same (rich dirt) and sowed the seed. The jar in which I used the bacteria came up stronger, showed a better color, grew faster and with a ranker growth, which has convinced me it is all you claim for it.

Yours very truly,

L. A. LEWIS.

ENDORSED BY
NEW YORK CITY FARM SUPERINTENDENT.

I made a test of Ferguson's Composite Culture of Nitrogen Fixing Bacteria. As Superintendent of the farm owned by the City of New York and conducted by the Department of Charities and Correction of New York City, in connection with the city penitentiary, I inoculated with this bacteria directly beans and peas, and used inoculated humus on lettuce, cucumbers, cabbage, beets and other vegetables. The results showed a marked increase where the inoculated seeds and humus were used as compared with the same kind of vegetables not inoculated. The increase in the crop certainly more than paid for the slight cost of applying the bacteria.

I shall be glad to avail myself of its use again as occasion arises, as I am confident that the system can be of great benefit to anyone who will properly use it.

D. CLARK.

RESULTS AMAZING.—Used inoculating material on clover, timothy and grass in hard clay soil, previous crop potatoes—we wished to make a lawn. The inoculating material left we mixed with sand and threw it over the rest of the place. The result was amazing—we had it cut numerous times, and last week it was in splendid condition.

MRS. C. T. HIPPEY, Roanoke, Va.

U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 315

"The peculiar value of legumes for increasing and maintaining the fertility of soils is due to certain bacteria which develop nodules upon the roots of leguminous plants and which have the unique power of rendering the free Nitrogen of the atmosphere available for plant growth. Without these bacteria, legumes, like other crops, exhaust the soil of its combined Nitrogen. In many regions certain types of these important bacteria are abundant in the soil; in other localities they must be imported, either by distributing soil from a field where they are known to be present, or by using pure cultures of the proper organisms grown under artificial conditions. The old method of importing bacteria by distributing soil from fields containing them is not only expensive, but there is a very great danger of spreading weeds and destructive crop diseases, as well as the desirable bacteria. Under modern conditions, therefore, it is wisest to depend chiefly upon the intelligent manipulation of pure cultures for inoculating leguminous crops.

"Recent improvements in the methods of preparing and distributing pure cultures for inoculating leguminous crops have obviated many of the difficulties previously experienced in their use."

PRICES OF FERGUSON'S COMPO
CULTURE NITROGEN-FIXING
BACTERIA

Available for Clovers, Alfalfa, Beans, Vetches, Lupines, Soy Beans, and other Legumes.

Bottle of bacteria sufficient to inoculate seed for one acre . . . . . .

Bottle of bacteria sufficient to inoculate seed for five acres . . . . . .

Small bottle of bacteria sufficient to inoculate garden or quarter acre . . .

The one acre package, also garden size can be sent through the mail. The five acre will be sent by express prepaid.

Orders will be filled by mail if sent direct Company, upon personal check, cash or mone enclosed.

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1046 DEFENDANT'S EXHIBIT 23.

THE EFFECTS OF NONBENEFICIAL NODULE BACTERIA ON AUSTRIAN WINTER PEA

BY

LEWIS T. LEONARD AND W. R. DODSON

(Contribution from Bureau of Chemistry and Soils)

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U. S. Government Printing Office : 1933

1047 TABLE 8.—NITROGEN FIXATION IN GREENHOUSE PLANTINGS OF AUSTRIAN WINTER PEAS

Inoculation treatment	Duration of experiment	Nodules per plant	Dry weight (50 plants)	Nitrogen	Total Nitrogen
		Average number	Grams	Per cent	Gram
None	Oct. 28, 1929 to Dec. 12, 1929 (45 days)	....	13.00	2.60	0.339
473		....	12.50	3.33	.416
484		....	12.50	2.38	.300
510		....	15.50	3.04	.471
511		....	23.00	2.94	.675
512		....	21.50	3.08	.664
513		....	21.50	2.15	.461
515		....	23.00	2.40	.550
518		....	20.50	3.09	.633
None	Feb. 14, 1931 to Apr. 8, 1931 (53 days)	3	15.60	1.30	.203
510		15	18.50	2.86	.532
511		16	20.75	2.74	.568
513		96	15.90	1.22	.194
518		13	26.85	2.36	.635
None	Apr. 4, 1931 to May 25, 1931 (51 days)	1	12.80	1.72	.220
512		15	13.80	2.70	.372
513		135	13.20	2.04	.269
548		90	11.40	1.66	.189
549		99	12.20	1.68	.205
550		122	11.60	1.66	.192
512+513		29	11.70	1.94	.227
513+$NaNO_3$		44	14.90		

In the first experiment, culture 510 apparently gave poor results, so far as dry weight and total nitrogen are concerned, yet the percentage of nitrogen rather closely parallels that of the other beneficial cultures. Considering matters on the basis of total nitrogen apparently fixed by nodule organisms, it will be noted that the plants from only one culture (484) contained less nitrogen than the control. Apparently the so-called nonbeneficial cultures were slightly beneficial when the quantity of nitrogen fixed is considered. However, in the second experiment the nitrogen fixed by the nonbeneficial culture (513) was actually less than that of the control and much less than that of any of the three beneficial cultures employed and in the last experiment this nonbeneficial culture was slightly better than the control. When the two types of organisms (512 and 513) were used together the total nitrogen fixed was not greater than that fixed by the nonbeneficial organism alone. However the addition of 0.1 per cent sodium nitrate to the solution originally used to moisten the sand (subsequent waterings being made without nitrogen additions) helped the plants inoculated with a nonbeneficial organism considerably.

Source of the Nonbeneficial Organisms

The fact is evident that nodule bacteria beneficial and detrimental to Austrian winter peas exist in some of the soils around Jeanerette, La., the nonbeneficial ones evidently predominating. In seeking an explanation for the presence of these organisms it was found that plants of Louisiana vetch (*Vicia ludoviciana* Nutt.) grew plentifully and luxuriantly around the fields and in waste places. The roots of these wild plants are well populated with nodules. It is therefore reasonable to believe that the organisms causing these nodules are abundantly present in the soil. It is customary to consider that the organisms of the common vetch will cross-inoculate with garden

1047 peas, field peas, Austrian winter peas, and other legumes although data concerning the group relations of Louisiana vetch have not been worked out. However, acting on the supposition that the bacteria of this legume are related to those of the Austrian winter pea but not satisfactorily adapted to the latter, the writers made isola-

tions from nodules for comparison with the nonbeneficial bacteria obtained from Austrian winter peas.

After the cultures from Louisiana vetch were purified they were applied to Austrian winter pea and Louisiana vetch seed in the greenhouse under controlled conditions, as indicated in Table 8. These cultures produced nodules on their specific hosts. The results with Austrian winter peas indicate that these Louisiana vetch nodule organisms produce the same effect as those of the nonbeneficial type whose effects have been previously noted in this paper. From April 4 to May 25, 1931, the Austrian winter-pea plants grown from seed treated with three cultures of nodule organisms of Louisiana vetch had much the same appearance as those from seed treated with a nonbeneficial culture isolated from Austrian winter pea nodules. (Fig. 3.) As compared with the control, Louisiana vetch organisms (548, 549, and 550) contributed no nitrogen to the Austrian winter peas; in fact they caused a slight loss. (Table 8.)

Nodules produced by Louisiana vetch cultures were plentiful, scattered, and globular. Nodules of this type are shown in Figures 4 and 5 in comparison with nodules produced by beneficial and nonbeneficial cultures from Austrian winter peas. Characteristic nodule assemblies are more distinct in greenhouse samples than in field samples. (Fig. 2.) Table 8 shows that the average number of nodules per plant is considerably higher when poor cultures of Austrian winter peas and Louisiana vetch were used than when beneficial organisms were used. The close similarity of response of Austrian winter peas to nodule organisms from Louisiana vetch and from apparently parasitized Austrian winter peas is indicative of the origin, of the unadapted strains present in the soils studied.

Summary

Cultures of nodule bacteria from poor and vigorous Austrian winter-pea (*Pisum arvense*) plants from Jeanerette, La., have been compared with nodule bacteria from closely related legumes in field and greenhouse tests.

Drainage obtained by ridging the soil had but little effect, and lime and basic slag had practically no effect on the crop produced.

A favorable well-defined effect in quantity and quality

of crop was evident in Austrian winter peas treated with efficient nodule bacteria in soil known to contain inefficient nodule-producing organisms.

Evidence has been presented which shows that the nodule organisms of the Louisiana vetch (*Vicia ludoviciana*) reduce the yield of Austrian winter pea on account of their unadaptability to this host.

1048 DEFENDANT'S EXHIBIT 24.

Reprinted from the Journal of the American Society of Agronomy, Vol. 17, No. 10, October 1925

SOME TESTS WITH SOILGRO[1]

LEWIS T. LEONARD[2].

"The quest continues for a mixed culture of soil bacteria which, when added to the soil, will exert an extraordinary stimulating effect on all plant growth. Starting with Alinite about 30 years ago, after the first successful trials in the inoculation of legumes with pure cultures of nodule bacteria, there have been produced preparations named Geonitrine, Nitrobacterine, Humogen, Phosphogerm, All Crop Farmogerm, Bac-su-muh, Biological Fertilizer, Hu-fi-

1049 teria, Nitragine, U-Kultur, Vitamite, Humophos, Nitrobacter Soil Vaccine, Dextrogerm, Verdure, and others for which far-reaching claims have been made. By the use of these preparations nitrogen from the air was said to be fixed in the soil and to be made available for all crops; while the transformation of the humus into carbon dioxide and soluble nitrogen compounds, as well as the unlocking of the insoluble mineral plant food present in the soils, was said to be stimulated to a great extent. However, most of these preparations have been very short-lived due to their inability to produce the results claimed for them. On the basis of properly controlled tests, none of them have been found to be worthy of recommendation.

[1] Contribution from Office of Soil-bacteriology and Plant-nutrition Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C. Received for publication July 25, 1925.

[2] Associate Physiologist.

Concerning the latest invention named "Soilgro," the following data have been obtained. This material was first brought to our attention in 1924 when its preliminary exploitation was taking place in Canada. At present it is being sold in the United States.

Previous Tests With Soilgro

Through correspondence with Dr. Dan H. Jones, Agricultural College, Guelph, Ontario, Canada, the information was obtained that Soilgro was tested at the College farm on various crops, but none of the effects claimed had become evident. Later, the Canadian bacteriologists issued a joint statement regarding their adverse opinions on the merits of materials such as Soilgro. A chemical test of this preparation by the Massachusetts experiment station[3] showed it to be worth about 1 cent in fertilizing value. Practically the same chemical results were obtained at the Connecticut experiment station,[4] and tests on grasses and lettuce there failed to give any evidence in favor of the use of this material.

Description of Soilgro and Directions For Use

Soilgro is shipped in cardboard packages containing one or four units of material. Each unit is marked with the date beyond which the material will not be of value. The packages contain two 1-gallon cans of similar rectangular shape, one green in color, holding the bacteria, the other, brown, containing the "bacteria food."

The liquid is light brown in color, smelling somewhat like a weak rain water solution of manure. In this respect, it resembles Nitrobacter Soil Vaccine which was recently on the market and which was found to be practically worthless. The bacterial food consists of sandy

soil mixed with rotted manure, containing about 40% moisture. Plant stems and balls of manure covered with a white substance, presumably lime, were noticeable. The material is not homogeneous.

[3] Haskins, H. D. Chemical facts about Soilgro. In Rural New Yorker, 84:831. 1925.

[4] Morgan, M. F. Some experiments with "Soilgro." In Rural New Yorker, 84:970. 1925.

The directions accompanying Soilgro advise adding 4 gallons of rainwater to the furnished ingredients and incubating for five days in a warm place. Soilgro prepared according to directions is advised for use on lawns which are already growing, in which case the material properly diluted is sprinkled on under favorable conditions of cloudiness and rainfall, or the grass seed to be planted is moistened with the material undiluted. Other seed are soaked from 3 to 12 hours, the first time applying to soft seed like peas and beans, the second to hard seed such as radishes. Its use is also advocated on hardy perennials, house plants, and trees.

The samples of Soilgro used in the tests reported were obtained as follows: Sample No. 1 by direct purchase from the Soilgro Products Company, New York City; sample No. 2 by donation through the courtesy of Mr. Davieson Power, president of the company; and sample No. 3 by purchase through an agent at Philadelphia, Pennsylvania.

Numbers of Bacteria In Soilgro

The literature accompanying Soilgro states that the mixture contains legume bacteria, nitrogen fixing, ammonifying, nitrifying, and decomposition bacteria.

In determining the numbers (Table 1) of bacteria, beef agar was used for ammonifying organisms, soil extract agar for the general soil organisms, and cellulose agar for the decomposition bacteria. Potting soil and rotted manure were run separately for a comparative purpose.

TABLE 1.—Numbers of bacteria per gram grown from Soilgro, Soilgro mixture, and other preparations on three different media.

Material	Beef agar	Soil extract agar	Cellulose agar
Soilgro, Sample No. 1	2,900,000	393,000	186
Soilgro, Sample No. 2	1,520,000	1,100,000	
Soilgro, Sample No. 3	800,000	530,000	
Bacterial food, Sample No. 1	127,000,000	142,000,000	14,500
Rotted manure	370,000,000	327,000,000	430,000
Potting soil	35,000,000	69,000,000	230,000
Soilgro mixture, Sample No. 1	2,000,000	500,000	
Soilgro mixture, Sample No. 2	2,445,000		
Soilgro mixture, Sample No. 3	1,020,000		
Bacterial food mixture, Sample No. 1	2,000,000	880,000	
Rotted manure mixture	5,500,000	2,240,000	
Potting soil mixture	9,000,000	1,720,000	

1050 Numbers of bacteria were calculated without reference to the moisture content of the soil, manure, and bacterial food. The mixtures of soil, manure, and bacterial food were prepared similarly to Soilgro.

The figures indicate that there are considerably more bacteria in the bacterial food, in ordinary potting soil, and in rotted manure than in the Soilgro liquid, either before or after preparation according to directions.

Character of the Bacteria

The bacteria found in Soilgro and Soilgro mixture did not differ materially from those found in the soil which was plated at the same time on beef and soil extract agar. Typical Azotobacter films did not develop in mannite solutions. Colonies occurred on soil extract agar which resembled *B. radicicola*, but absolute proof of the presence or absence of certain strains of this organism is given in Table 2 which is a compilation of data from vegetative tests made under controlled conditions with potting soil and with Soilgro.

TABLE 2.—Strains of legume bacteria found in Soilgro.[a]

Inoculation	Nodule production on				
	Alfalfa	Red Clover	Cowpea	Soybean	Vetch
Potting soil	+	+	—	+	+
Bacterial food, Sample No. 1	—	+	—	—	+
Soilgro, Sample No. 1	+	+	—	—	—
Soilgro, Sample No. 2	+	—	—	—	+
Soilgro, Sample No. 3	+	+	—	—	—

[a] + indicates the organisms were found.
— that they were not found.

Nitrogen Fixation and Transformation

By the use of the standard methods of the Laboratory of Soil Bacteriology for the determination of the power of a culture to assimilate and transform nitrogen, tests[5] were made with the undiluted original samples of Soilgro bacteria, with the mixtures prepared according to directions, and with the bacterial food, as well as with potting soil for comparison. The incubation periods for the fixations and transformations were 10 and 20 days, respectively. The results are given in Tables 3 and 4.

[5] Nitrogen analyses were made by Klare S. Markley.

TABLE 3.—Nitrogen assimilation by soil and Soilgro.

Inoculum	Nitrogen in medium and inoculum mgs.	Nitrogen after 10 days' incubation mgs.	Net gain in nitrogen mgs.
5 grams of potting soil	11.8	14.9	3.10
5 grams bacterial food, Sample No. 1	14.0	15.6	1.60
5 cc. Soilgro, Sample No. 1	3.8	3.9	0.10
5 cc. Soilgro, Sample No. 2	1.1	1.7	0.60
5 cc. Soilgro, Sample No. 3	1.1	3.3	2.20
5 cc. Soilgro mixture, Sample No. 2	1.8	2.2	0.40
5 cc. Soilgro mixture, Sample No. 3	2.1	2.5	0.40

TABLE 4.—Transformation of ammonium salts to nitrate by soil and Soilgro.

Inoculum	Type of media	Nitrogen as nitrate in medium and inoculum mgs.	Nitrogen as nitrate after 20 days' incubation mgs.	Net production of nitrogen as nitrate mgs.
5 grams of potting soil	Liquid 50 cc. $(NH_4)_2HPO_4$	1.40	7.50	6.1
5 grams bacterial food, Sample No. 1	Liquid 50 cc. $(NH_4)_2HPO_4$	1.15	3.75	2.6
5 cc. Soilgro, Sample No. 1	Liquid 50 cc. $(NH_4)_2HPO_4$	1.60	5.80	4.2
5 cc. Soilgro, Sample No. 2	Soil 50 grams $(NH_4)_2SO_4$	9.0	10.6	1.6
5 cc. Soilgro, Sample No. 3	Soil 50 grams $(NH_4)_2SO_4$	9.0	11.0	2.0
5 cc. Soilgro mixture, Sample No. 2	Soil 50 grams $(NH_4)_2SO_4$	9.0	9.6	0.6
5 cc. Soilgro mixture, Sample No. 3	Soil 50 grams $(NH_4)_2SO_4$	9.0	9.6	0.6

A Vegetative Test With Radishes

Radish seed were soaked in the prepared solution of Soilgro bacterial food, soil, and manure for 12 hours, and then duplicate boxes were planted in uniform soil, 100 properly spaced seed to each box. The result from the first harvest of marketable radishes is given in Table 5.

TABLE 5.—First crop of marketable radishes from seed treated with Soilgro and other mixtures.

Treatment	Number of radishes of suitable size		Total weight in grams, including tops		Average weight in grams per radish
	Box 1	Box 2	Box 1	Box 2	
None	22	33	132	224	6.47
Soilgro mixture, Sample No. 1	30	34	190	244	6.78
Bacterial food mixture, Sample No. 1	30	33	213	242	7.22
Rotted manure mixture	26	32	189	231	7.24
Potting soil mixture	32	27	213	199	7.00

The small differences observed do not indicate that the Soilgro preparations have exerted any beneficial effect
628 Journal of The American Society of Agronomy
1051 upon the development of the test plants. This finding is confirmed by the data presented in Table 6.

TABLE 6.—Total crop of radishes from seed treated with Soilgro and other mixtures.

Treatment	Numbers		Total weight in grams, including tops		Average weight in grams per radish
	Box 1	Box 2	Box 1	Box 2	
None	82	82	519	599	6.82
Soilgro mixture, Sample No. 1	80	77	525	554	6.87
Bacterial food, Sample No. 1	73	81	518	542	6.88
Rotted manure mixture	81	71	564	536	7.24
Potting soil mixture	74	71	393	519	6.29

The figures given in the "numbers" column of Table 6 show no great variations in germination and also indicate that the soaking of the seed has not been of advantage in this case.

A Test With Garden Peas

Peas were soaked three hours in the Soilgro mixture and in other mixtures for comparison. They were planted in the field on a rather heavy clay soil. All seed germinated about the same time. Doves and pigeons dug up some of the seed, thereby making it necessary for comparative purposes to calculate the crop on the basis of the weight per plant. Unfortunately, dry weather interfered with the development of this crop. The results are given in Table 7.

TABLE 7.—Crop of peas from plats with various treatments.

Treatment	Number of plants	Total weight in grams of peas in pods	Average weight in grams of peas per plant
Soilgro mixture, Sample No. 1.....	257	363	1.41
Bacterial food mixture, Sample No. 1	278	547	1.96
Rotted manure mixture.....	279	564	2.02
Potting soil mixture.....	278	565	2.03

A Test On Lawns

The treatment of lawn grass with Soilgro has been tried on the grass garden at the Arlington Farm by the Office of Forage Crop Investigations. The plats treated with So gro and bacterial food exhibit a superficially noticeable inferiority to the plats treated with ammonium sulfate.

In another experiment, eight plats of 10 feet by 10 feet each were treated with the preparations heretofore mentioned in duplicate in accordance with the instructions. Each application was made under favorable conditions. At no time during the period following treatment were any superficial differences between the plats noted. As

a quantitative index of the effects of the treatments, the cuttings of the grass from the various plats were dried and weighed. One cutting was made before the first application and the other 26 and 12 days, respectively, after the first and second application of material. Only one application of the manure mixture was made. The results are given in Table 8.

TABLE 8.—Dry weights of grass grown on plats treated with Soilgro and other preparations.

Plat	Treatment	Weight of crop in grams before treatment	Average in grams	Weight of crop in grams after two treatments	Average in grams
2	Soilgro mixture,	403	306	293	254
5	Sample No. 1	208		214	
3	Bacterial food mixture,	226	297	320	347
6	Sample No. 1	367		373	
1	Rotted manure	280	207	292	268
8	mixture	134		244	
4	Potting soil mixture	182	268	238	301
7		354		364	

Summary

1. The total numbers of bacteria in the Soilgro cultures tested were found to be much lower than those in the so-called bacterial food accompanying the liquid cultures. Soil and manure samples plated for comparison gave higher figures.

2. The numbers of ammonifying and cellulose destroying bacteria were also larger in bacterial food, soil, and manure samples than in the Soilgro cultures. The presence of Azotobacter in the culture was not indicated by the tests made. Certain strains of legume bacteria were found in Soilgro, but in less number than in the potting soil used for comparison.

3. Nitrogen fixation by potting soil was superior to the fixation by a Soilgro culture, and the mixtures of Soilgro gave a lower fixation in two cases than the culture from which they were made.

4. The nitrification of ammonium salts in liquid and in soil cultures was better by potting soil than by any of the Soilgro preparations.

5. Soilgro showed no superiority in the production of radishes, either in the stimulation of germination, earliness of crop, or weight of crop collectively or individually. Tests made with peas were likewise negative.

6. Two tests on lawns did not produce results favorable to Soilgro. Quantitative tests on cuttings made from treated plats bore out the results of superficial examination.

1052 DEFENDANT'S EXHIBIT 25-A,

(Offered but not received in evidence.)

Canada

Division of Bacteriology and Dairy Research — Science Service

DEPARTMENT OF AGRICULTURE
Central Experimental Farm
Ottawa

Dr. A. W. Hofer, May 22, 1945.
Division of Bacteriology,
New York Agricultural Experiment Station,
Geneva, N. Y.

Dear Dr. Hofer:

I have your letter of May 18th, regarding the practicability of preparing composite culture inoculants, that is those which are able to cause nodulation on more than one of the cross-inoculation groups.

The matter is one on which there are surprisingly few data available in the literature, as far as I have been able to judge. Fred, Baldwin and McCoy have little to say on this question, and what they do say suggests that the disadvantages out-weigh the advantages. Wilson's book on Symbiotic Nitrogen Fixation also emphasizes the scarcity of data, while Bond (J. Bact. 36: 306) gives little in the way of supporting data in recommending composite cultures.

During the course of the last seven or eight years we have had occasion to check a few composite cultures for nodulation. Out of five tests we found that in four cases nodulation on red clover was considerably less satisfactory than on alfalfa plants, and in one case the reverse was true. However, I do not think that the differences in effectiveness noted provide any satisfactory evidence either for or against the hypothesis of antagonism between different species of Rhizobia, because we have no data on the use of the same cultures singly. Single cultures might or might not have given the same results. The above tests to which I refer had to do with the percentages of plants nodulated when the cultures were used as directed. No information was obtained as to nitrogen-fixation.

Regretting we have no further data on this important practical problem, I am,

Yours sincerely,
(signed) A. G. Lochhead,
A. G. Lochhead,
Dominion Agricultural Bacteriologist.

AGL/F

1057 DEFENDANT'S EXHIBIT 25-B

(Offered but not received in evidence.)

Division of Bacteriology

NEW YORK STATE AGRICULTURAL EXPERIMENT STATION
Cornell University
Geneva, New York
A. J. Heinicke, Director

Geneva, N. Y., June 7, 1945

Dr. Alvin Hofer,
Agricultural Experiment Station,
Geneva, New York.

Dear Dr. Hofer:

I do not know of any data showing that one kind of legume nodule bacteria has an inhibitory effect on another. It is true that the earliest commercial inoculants contained only one variety each, but this seems to have been due to two circumstances only: first, the bacteriologist never feels that it is wise, in the laboratory, to use anything but pure cultures, and accordingly the advice given to the industry (until subsequent study showed it to be unnecessary) was to furnish the farmers with pure cultures; second, to avoid confusion on the part of the farmer, it seemed best to mark each inoculant as adapted to the one kind of legume on which it worked *best*. As early as 1931, however, commercial producers of these inoculants began putting mixed cultures on the market, and the success of these mixed cultures, in practice, seems to have disproved any possible claim that inhibition occurs when such varieties are combined in one culture.

Furthermore, we know that in many soils nodules are produced on the roots of several different kinds of legumes; this is absolute proof that the several varieties of nodule bacteria live together in soil without harming each other. There is no conceivable reason why they cannot do so in inoculants also.

Please note that I say "varieties" not "species". I use the former term, because students of this group are uncertain whether there is more than one species of *Rhizobium*, and in case there is more than one whether there are many or just two or three.

Sincerely,

(signed) H. J. Conn.
H. J. Conn.

HJC:bb

1056 DEFENDANT'S EXHIBIT 25-C.

(Offered but not received in evidence.)

Department of Bacteriology

THE PENNSYLVANIA STATE COLLEGE

School of Agriculture

State College, Pennsylvania

June 8, 1945

Dr. A. W. Hofer,
New York State Agricultural Experiment Station,
Cornell University,
Geneva, New York.

Dear Dr. Hofer:

I do not agree with the belief that one species of Rhizobium may exert a definite inhibitory effect upon another species of the genus. I do agree with the belief that it is not wise to cultivate two or more species together as one may so outgrow the other or others that only the rank grower will be present in significant numbers. This holds for any similar mixture of closely related organisms as for example mixtures of *E. coli* and *A. aerogenes.*

In so far as mixing two species of Rhizobium after growth is concerned, as for example might easily be done in humus preparations, it is my considered opinion that no adverse effects will take place and if used within a reasonable length of time such a mixture should be effective for all cross-inoculation groups concerned. I am opposed to the sale of such preparations as a rule because when one is inoculating soybean seed for example there would be no benefit in paying for another group which would not be useful.

Sincerely,

(signed) J. J. Reid,
J. J. Reid,
Associate Professor.

JJR:au

1053 DEFENDANT'S EXHIBIT 25-D.

(Offered but not received in evidence.)

College of Agriculture Department of Soils

UNIVERSITY OF MISSOURI
Columbia

May 29, 1945

Dr. A. W. Hofer
Division of Bacteriology
Agricultural Experiment Station
Geneva, New York

Dear Dr. Hofer:

We have your letter of the 18th inquirying about the possibility of using composite cultures and cross inoculating groups for seed treatment.

In our own experience we have found the cultures from one plant group serving very effectively when used on others in the cross inoculation classification as we now know it. The specificity of a culture, grown in the laboratory, on the plant out in the soil is a matter which seems to have been strained a bit in our desires to work out so many classifications. The work of Dr. Wilson has pointed forcefully to the fact that cross inoculations are wider in Nature than we are wont to believe.

In our own studies, the physiology of the plant has given it a decided prominence in determining whether it is inoculated or not. The particular kind of bacteria has had so much attention and so little attention has gone to the nutritional level of the plant that I am inclined to believe that we have emphasized our bacterial cultures too much and that the fertility of the soil into which these cultures are put has been emphasized altogether too little.

When different microorganisms live in the soil as a mixture, the matter of their living together in a culture deserves the belief that they get along together. This whole matter of excessive emphasis on the culture as to its specificity for one plant species is mainly a matter of the conditions of the laboratory. If we have the micro-organisms truly growing, only small numbers of them are needed to be effective on the plant if the plant conditions are favorable.

Yours very truly,
Wm. A. Albrecht,
Chairman,
Department of Soils.

1054 DEFENDANT'S EXHIBIT 25-E.

(Offered but not received in evidence.)

Department of Agronomy

University of Illinois
COLLEGE OF AGRICULTURE
Agricultural Experiment Station
Urbana, Illinois

May 26, 1945

Dr. A. W. Hofer,
Division of Bacteriology,
New York Agricultural Experiment Station,
Cornell University,
Geneva, New York.

Dear Doctor Hofer:

Our studies have not proved that one species of legume nodule bacteria has an inhibitory effect on other species. Because we have not studied all strains of Rhizobium leguminosarum it is not possible to state what effect "certain strains of certain species of the Rhizobia have on each other".

Very truly yours,
O. H. Sears,
Chief, Soil Biology.

OHS:pk

1058 DEFENDANT'S EXHIBIT 25-F.

(Offered but not received in evidence.)

State of New Jersey
AGRICULTURAL EXPERIMENT STATION
William H. Martin, Director
New Brunswick, N. J.

May 21, 1945

Dr. A. W. Hofer,
Div. of Bacteriology,
N. Y. Agr. Exp. Station,
Geneva, New York.

Dear Dr. Hofer:

I am in receipt of your letter of May 18 in regard to the lawsuit involving the two inoculant companies. I am very much surprised to learn that a company should make statements in regard to the effect of one legume organism upon another merely because the two exist in mixed culture. As far as our present knowledge is concerned, we have no evidence whatsoever that such an effect is taking place. This is sheer speculation and is not based upon either experimental evidence or upon practical observation.

There is no doubt that under natural conditions certain organisms have an inhibitory effect upon the growth of others, but these phenomena are exceptions rather than the rule. Although the possibility is not excluded that certain soil organisms may have some injurious effects upon legume bacteria, the possibility of the injurious effect of one legume organism upon another is, as I indicated above, rather speculative. One can even suggest that possibly one legume organism has a *favorable*, rather than injurious, effect upon another since such phenomena are quite abundant in nature.

Hoping that this information will be of interest to you, I am

Sincerely yours,
(sgd) Selman A. Waksman,
Microbiologist.

SAW:vab

1055 DEFENDANT'S EXHIBIT 25-G.

(Offered but not received in evidence.)

Soils Section Department of Ogronomy
THE STATE COLLEGE OF WASHINGTON
Pullman, Washington

College of Agriculture and
Agricultural Experiment Stations

May 23, 1945

Dr. Alvin W. Hofer,
Division of Bacteriology,
New York Agricultural Experiment Station,
Geneva, New York.

Dear Dr. Hofer:

With reference to your letter of May 18 I regret to state that we have made no exhaustive studies of the inhibitory effect of certain species of legume nodule bacteria on other species or cultures of the legume nodule bacteria when grown together. Judged from the results of the investigational work we have conducted along this line we have no reason for believing that one species of the legume nodule bacteria exerts significant inhibitory effects on other species of this group when grown together.

It is true that some species of bacteria in this group make more vigorous growth than others when grown separately on identical culture media, and it might be expected that this will occur also when they are grown together on the same culture medium.

Very truly yours,
(sgd) S. C. Vandecaveye,
Professor of Soils.

SCV:je

1059 DEFENDANT'S EXHIBIT 25-H.

(Offered but not received in evidence.)

HANSEN INOCULATOR CO.
(Hansen's Inoculator)
Trademark
808 North Lincoln Avenue
Urbana, Illinois

May 23, 1945

Dr. Alvin W. Hofer,
Division of Bacteriology,
N. Y. State Agr. Exp. Station,
Geneva, New York.

Dear Sir:

Replying to your letter of May 18, I have numbered the sentences in the patent referred to and given my reply immediately below.

1. "It has heretofore been considered impracticable to prepare a composite culture inoculant containing organisms which will cause nodulation on more than one of the cross-inoculation groups."

A. This is not true. As a matter of fact, several companies, including ourselves, were manufacturing and selling garden packets containing at least three groups for some years before the patent was taken out.

2. "This has not been done because it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented."

A. This is not true. No such inhibitory effect has ever been proved. No such inhibitory effect occurs in soils. For example, alfalfa bacteria, clover bacteria and soybean bacteria will live in the same soil without inhibitory effect one to the other. Reduction
1060 in numbers does occur and the chief factor responsible is very generally agreed to be the soil acidity. Other factors are fertility level of the soil, moisture conditions and temperature (alternate freezing and thawing). There is no reason to believe that the nodule bacteria behave differently in a culture

than in ordinary soils. After all, the finely ground, kiln dried peat most commonly used as a base in preparing commercial cultures is an organic soil.

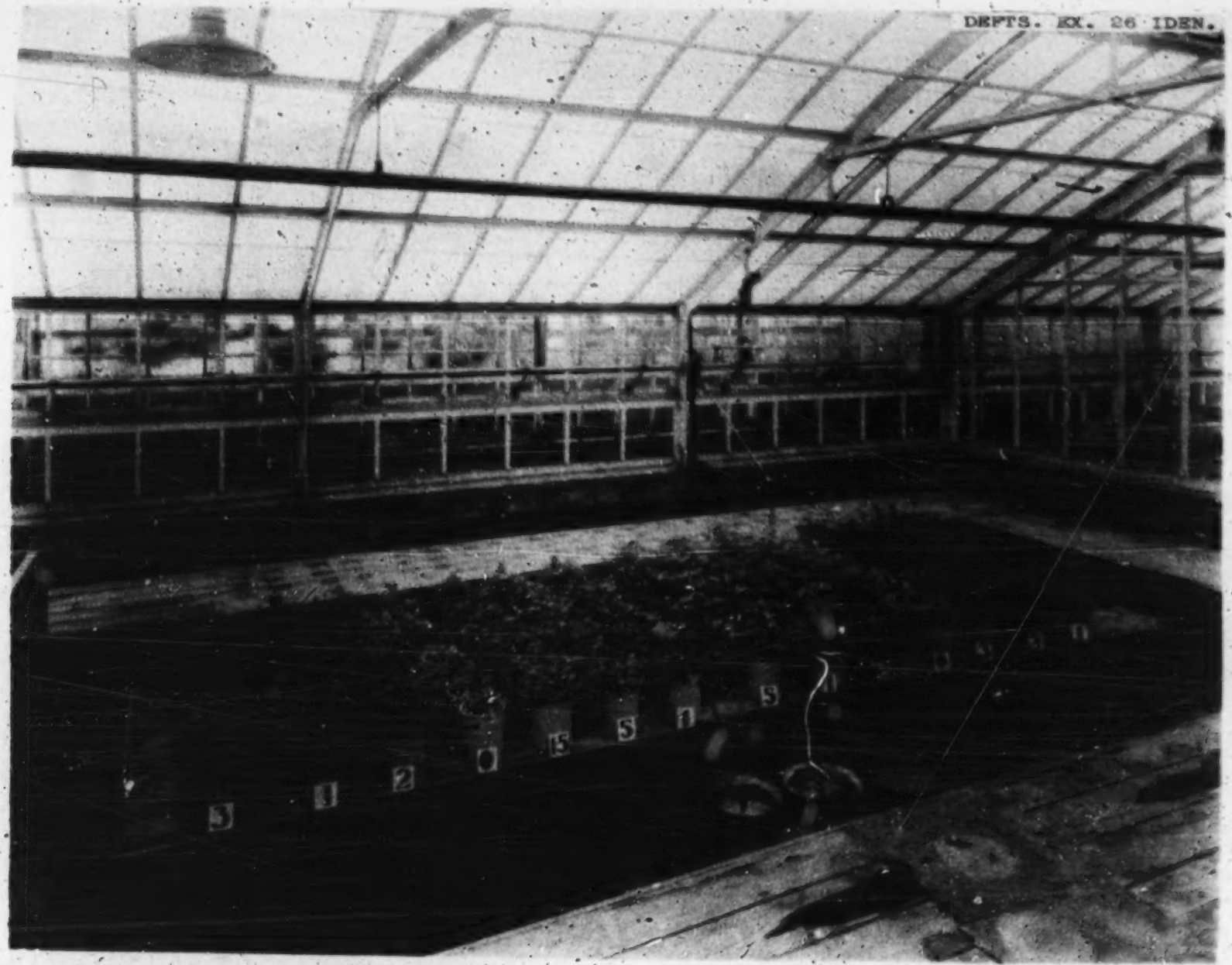
3. "For this reason, it has been considered desirable to use a culture containing a single species of organism rather than one containing a mixture."

A. The reason single species cultures have been considered most desirable for cultures for field seeds is that the peat base will only take up so much moisture (35 to 40 per cent), and to get enough bacteria into a given amount of peat base only one species is used. If you use three species, the numbers of bacteria of each group is reduced to one-third. If you triple the size of the package to get the proper numbers for each group, the farmer gets into trouble in applying so much peat-base inoculant to a given amount of seed. Production costs also enter in the picture; two-thirds of the contents of each package is pure waste, since in almost every case the contents of the package is used on one kind of seed. The objections to the use of composite cultures for field seeds does not apply to garden seeds. In garden packets the amount of inoculant is much greater in proportion to the amount of seed; and garden seeds are very generally hand planted, so the difficulty in seeding does not occur.

1061 Finally, it is my considered judgment that the only advantage in composite cultures for field seeds lies in the reduction of returns by dealers. If the dealer fails to sell the package for alfalfa or sweet clover, he may be able to sell it for clovers; if he fails to sell it for either of these groups, he may sell it for soybeans. The advantage is to the dealer and not to the farmer who is the ultimate consumer. This fact becomes obvious when one examines the advertising by makers of composite cultures in seed trade journals.

Yours very truly,
(sgd) Roy Hansen.

RH:agt


DEPTS. EX. 26 IDEN.
664-665

DEFTS. EX. 27 IDEN.

699-999

DEFTS. EX. 28 IDEN
668-669

1065 DEFENDANT'S EXHIBIT 29.

CLOVER PLANTS

WEIGHTS EXPRESSED IN GRAMS

	a	b	c	d	e	f	g	h
1 Tops	15.0	12.9	12.2	11.6	12.4	13.2	15.7	11.0
1 Roots	12.2	6.9	7.3	7.3	9.0	8.2	11.9	9.1
1 Total	27.2	19.8	19.5	18.9	21.4	21.4	27.6	20.1
2 Tops	23.9	13.6	10.5	10.8	12.8	12.3	12.7	8.3
2 Roots	8.9	9.2	5.8	5.1	8.0	7.8	7.7	10.0
2 Total	32.8	22.8	16.3	15.9	20.8	20.1	20.4	18.3
3 Tops	18.9	15.7	12.8	9.3	16.0	9.3	16.4	13.6
3 Roots	12.2	9.9	8.6	17.3	9.4	6.5	9.7	9.1
3 Total	31.1	25.6	21.4	26.6	25.4	15.8	26.1	22.7
4 Tops	19.3	6.7	10.6	15.0	16.2	10.5	12.7	16.0
4 Roots	13.6	12.7	5.6	8.5	13.4	4.7	6.2	10.5
4 Total	32.9	19.4	16.2	23.5	29.6	15.2	18.9	26.5
5 Tops	16.4	18.0	12.9	15.5	13.6	11.2	11.1	12.8
5 Roots	12.3	9.2	6.0	7.7	8.6	9.1	8.7	13.3
5 Total	28.7	27.2	18.9	23.2	22.2	20.3	19.8	26.1
1–15 Tops	22.9	14.3	19.3	12.5	10.4	17.1	14.0	14.5
1–15 Roots	11.1	8.2	9.7	6.7	5.5	13.3	7.2	11.1
1–15 Total	34.0	22.5	29.0	19.2	15.9	30.4	21.2	25.6
0 Tops	1.0	0.4	0.5	0.5				
0 Roots	2.5	1.9	2.0	2.5				
0 Total	3.5	2.3	2.5	3.0				

CLOVER PLANTS

WEIGHTS EXPRESSED IN GRAMS

Total	Average	% N	Total N % 8 pots	Total
104.0	13.0	3.22	3.35	
71.9	9.0	2.47	1.77	
	22.0		5.12	5.12
104.9	13.1	3.33	3.49	
62.5	7.8	2.28	1.43	
	20.9		4.92	4.92
112.0	14.0	3.15	3.53	
82.7	10.34	2.20	1.82	
	24.34		5.35	5.35
107.0	13.8	3.22	3.45	
75.2	9.4	2.39	1.80	
	23.2		5.25	5.25
111.5	13.9	3.42	3.81	
74.9	9.36	2.33	1.75	
	23.26		5.56	5.56
125.0	15.6	3.42	4.27	
72.8	9.1	2.22	1.62	
	24.7		5.89	5.89
2.4	0.6			
8.9	2.2	0.97	0.218	0.218
11.3	2.8			

1066 DEFENDANT'S EXHIBIT 30.

COMPARISON OF TYPES OF CULTURES BASED UPON TESTS MADE IN NEW YORK STATE

	Cultures for one plant group		Garden cultures	
Year	Number tested	Number Unsatisfactory	Number Tested	Number Unsatisfactory
1933	51	7	7	4
1934	64	6	11	3
1935	59	14	6	1
1936	98	4	10	1
1937	90	2	7	2
1938	99	1	11	1
1939	60	1	1	0
1940	57	1	4	0
1941	56	1	8	0
1942	68	3	5	0
1943	71	0	6	0
1944	54	1	8	0

One company at least produced good garden cultures so long as these were tested.

With the exception of one brand that had two unsatisfactory garden cultures in one year, the quality of these has been good.

1067 DEFENDANT'S EXHIBIT 31.

YIELD OF LIMA BEANS FROM TWO TYPES OF INOCULANTS

Type of culture	Total Yield in Grams							
	1941			Aver-	1942			Aver-
	Row 1	Row 2	Row 3	age	Row 1	Row 2	Row 3	age
None	733	891	1309	968	1945	1190	2034	1723
Lima Bean	1375	1603	1932	1637	1530	2460	1685	1892
Lima Bean	1385	1549	1246	1397	1914	1945	2142	2000
Mixed	2414	2255	2410	2293	2851	3203	2135	2730
Mixed	2323	1183	1161	1556	2925	2304	1777	2335
Mixed					1964	2217	1575	1919

The average yield of the two mixed cultures tested in 1941 is found to be 1924 grams per row, as contrasted to the 1517 grams of the lima bean cultures; in 1942, it is 2328 grams for the mixed culture, and 1946 grams for the lima bean cultures. These results are similar to those obtained in 1942 with beans. Thus, in every test so far made, the culture containing nodule bacteria for more than one group of legumes have outyielded those made for a single group. These results indicate that nitrogen fixation by bacteria from mixed cultures can be as good as that of bacteria from the more traditional type of inoculant. If the various groups of nodule bacteria packed together in one container had any effect on each other in these instances, this would appear to have been favorable.

AGRICULTURAL BULLETIN

Published monthly by the Department of Agriculture and Markets of the State of New York

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ALBANY, N. Y. NOVEMBER, 1934

Bulletin 292

Report of Analyses of Samples of Seed Collected in New York State July 1, 1933, to June 30, 1934

Defendant's No. 32
F.T.C.

Also

Report on Legume Inoculant Tests Made in 1934

(Pages 68 to 72 inclusive)

LEGUME INOCULANT TESTS FOR 1934

This report includes the results of tests upon legume inoculants purchased during 1934. As in previous years, these were secured by an inspector of the Bureau of Food Control, of the Department of Agriculture and Markets, in the seed stores and other places of sale in the State. The total number was 75, all of which were tested in the laboratories and greenhouses of the New York State Agricultural Experiment Station at Geneva.

Tests for Legume Inoculants

There are, in general, two types of legume inoculants, and these are tested by different methods. One type consists of such materials as agar and sand which carry the bacteria in pure culture; the other, of unsterilized peat or soil to which the bacteria are added.

Methods: Those cultures which were known to carry the bacteria in pure culture were tested by both laboratory and greenhouse methods. In the laboratory, bacterial counts were made by use of culture plates, and tests to detect presence of foreign bacteria were carried out in every case. If foreign bacteria were present, the estimation of numbers was not carried out. In the other type of culture, where foreign bacteria were always present, plate counts could not be made, in spite of the fact that such a count is of valuable assistance in the determination of the quality of a culture.

Greenhouse tests were the same for both types of culture, and were carried out in the same way as last year, with the exception that only two dilutions were used for the inoculation of the plants. These consisted of the one recommended by the manufacturer on the label, and another consisting of $\frac{1}{10}$ that quantity of inoculum. Some of the tests, however, were carried out on two host plants. Thus, in the case of alfalfa inoculants, tests were carried out on alfalfa and sweet clover. In the clover group, alsike clover was the second plant used. The red clover and alfalfa were grown in half-gallon pots, as in other years; the sweet clover and alsike clover were grown in tumblers which were kept covered the first two weeks with the top of a culture plate of the type used in the laboratory tests. This protected the plants against contamination with bacteria from other pots in the greenhouse and thus proved a distinct advantage.

Results: The 1934 tests are reported in detail in Table I. It will be seen that although great improvement in quality has been made, there is still an occasional unsatisfactory culture. While the presence of unsatisfactory cultures is an indication that a change in the method of manufacture is necessary, it is, nevertheless, extremely difficult for a manufacturer to produce inoculants that are reliable in 100 per cent of the cases. For this reason, a product should not be judged too severely upon the basis of one inferior sample.

Tests of Non-specific Inoculants

Methods: In addition to the usual tests, an examination was made of a culture which was claimed to be useful for inoculation of a number of crops, including non-legumes. For this test two poor soils were selected, and two crops, corn and soybeans, were grown. Poor soils were used because any response would be greater in a poor soil than in a rich one. Upon each soil, and with each crop, five treatments were used. In every case, extreme care was used in following the directions on the label.

The first treatment consisted of soaking the seeds in ordinary water, because if the growth were increased it might easily be the result of rapid germination due to soaking. The second set in each case was soaked in a 1:5 solution of the inoculant. The third was untreated. The fourth was treated the same as the second with the exception that the inoculant was added to the roots also. The fifth set was treated exactly like the fourth except that the inoculant was sterilized before application to the seeds and plant roots. The plants were watered with ordinary tap water as it was needed, and when the plants had reached the limit of their growth, they were carefully removed from the sand, dried, and weighed.

Results: When the dried plants were weighed, it was found that there were no great differences between the series, except for number five. In one or two cases, a distinct increase in growth occurred in this series, but since every application of the inoculants to number five had been sterilized previously, the results can hardly be ascribed to the bacteria in the culture. For these reasons, permission to sell this brand in the State was refused.

Conclusions

The quality of legume inoculants on sale in this State is reaching the point at which it should be maintained. There is apparently still some difficulty in the production of inoculants of uniformly high quality, but under the stimulus of the tests, and by cooperation between manufacturers and those engaged in the tests, the situation in New York State has shown steady improvement. In addition to the tests of products now on sale in the State, a close watch is necessary for protection against new untested products which may be introduced.

In view of the fact that few of the other States exercise any control whatever over legume inoculants, farmers are urged to buy these products only through dealers in New York State.

TABLE 1—RESULTS OF LEGUME CULTURE TESTS, 1934

Sample number	Brand	Group	Bacterial count*	Nodule Formation†		Conclusions
				With 1/10 the recommended inoculum	With the recommended inoculum	
148	Nod-O-Gen	Alfalfa	S	S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
157	Nod-O-Gen	Alfalfa	S	S	S	Satisfactory
		Sweet clover		I	S	Satisfactory
161	Nod-O-Gen	Alfalfa	S	S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
175	Nod-O-Gen	Alfalfa	S	S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
178	Nod-O-Gen	Alfalfa	S	S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
149	Nod-O-Gen	Red clover	S	S	S	Satisfactory
		Alsike clover		U	S	Satisfactory
156	Nod-O-Gen	Red clover	S	S	S	Satisfactory
		Alsike clover		S	S	Satisfactory
160	Nod-O-Gen	Red clover	S	S	S	Satisfactory
		Alsike clover		S	S	Satisfactory
155	Nod-O-Gen	Pea	S	S	S	Satisfactory
162	Nod-O-Gen	Pea	S	S	S	Satisfactory
154	Nod-O-Gen	Soybean	S	S	S	Satisfactory
163	Nod-O-Gen	Soybean	S	S	S	Satisfactory
192	Nod-O-Gen	Bean	S	S	S	Satisfactory
193	Nod-O-Gen	Bean	S	S	S	Satisfactory
191	Nod-O-Gen	Pea	S	S	S	Satisfactory
		Bean		S	S	Satisfactory
		Lima bean		S	S	Satisfactory
194	Nod-O-Gen	Pea	S	S	S	Satisfactory
		Bean		S	S	Satisfactory
		Lima bean		S	S	Satisfactory
201	Nod-O-Gen	Cowpea	S	U	U	Unsatisfactory
135	G. L. F.	Alfalfa	U	U	U	Unsatisfactory
		Sweet clover		U	U	Unsatisfactory
144	G. L. F.	Alfalfa	P	S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
153	G. L. F.‡	Alfalfa	S	I	I	Inconclusive
		Sweet clover		I	I	Inconclusive
167	G. L. F.‡	Alfalfa	U	U	U	Unsatisfactory
		Sweet clover		U	U	Unsatisfactory
303	G. L. F.	Alfalfa	U	U	U	Unsatisfactory
		Sweet clover		U	U	Unsatisfactory
158	G. L. F.	Red clover	S	S	S	Satisfactory
		Alsike clover		I	S	Satisfactory
166	G. L. F.	Red clover	P	S	S	Satisfactory
		Alsike clover		U	S	Satisfactory
186	G. L. F.‡	Red clover	S	S	S	Satisfactory
		Alsike clover		S	S	Satisfactory
197	G. L. F.‡	Red clover	S	U	S	Satisfactory
		Alsike clover		U	S	Satisfactory
190	G. L. F.‡	Red clover	S	S	S	Satisfactory
		Alsike clover		U	S	Satisfactory

TABLE 1 — RESULTS OF LEGUME CULTURE TESTS, 1934 — (*Continued*)

Sample number	Brand	Group	Bacterial count	Nodule Formation †		Conclusions
				With 1/10 the recommended inoculum	With the recommended inoculum	
202	G. L. F.	Red clover	U	U	U	Unsatisfactory
		Alsike clover		U	U	Unsatisfactory
152	G. L. F.	Pea	P	S	S	Satisfactory
190	G. L. F.‡	Pea	S	S	S	Satisfactory
196	G. L. F.‡	Pea	S	S	S	Satisfactory
173	G. L. F.‡	Soybean	S	S	S	Satisfactory
174	G. L. F.‡	Soybean	P	S	S	Satisfactory
200	G. L. F.‡	Soybean	S	S	S	Satisfactory
136	Nitragin	Alfalfa		S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
150	Nitragin	Alfalfa		S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
137	Nitragin	Red clover		U	S	Satisfactory
		Alsike clover		S	S	Satisfactory
151	Nitragin	Red clover		U	S	Satisfactory
		Alsike clover		S	S	Satisfactory
138	Nitragin	Pea		S	S	Satisfactory
176	Nitragin	Pea		S	S	Satisfactory
139	Nitragin	Soybean		S	S	Satisfactory
189	Nitragin	Soybean		S	S	Satisfactory
177	Nitragin	Pea		U	S	Satisfactory
		Bean		S	S	Satisfactory
		Lupine		S	S	Satisfactory
185	Nitragin	Pea		S	S	Satisfactory
		Bean		S	S	Satisfactory
		Lupine		S	S	Satisfactory
187	Nitragin	Pea		S	S	Satisfactory
		Bean		S	S	Satisfactory
		Lupine		S	S	Satisfactory
188	Nitragin	Lespedeza		S	S	Satisfactory
168	Nodule-Bacter	Alfalfa	S	U	S	Satisfactory
		Sweet clover		U	S	Satisfactory
179	Nodule-Bacter	Alfalfa	S	S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
169	Nodule-Bacter	Red clover	S	S	S	Satisfactory
		Alsike clover		S	S	Satisfactory
180	Nodule-Bacter	Red clover	S	S	S	Satisfactory
		Alsike clover		S	S	Satisfactory
170	Nodule-Bacter	Pea	S	S	S	Satisfactory
181	Nodule-Bacter	Pea	S	S	S	Satisfactory
172	Nodule-Bacter	Soybean	S	S	S	Satisfactory
183	Nodule-Bacter	Soybean	S	S	S	Satisfactory
171	Nodule-Bacter	Bean	S	S	S	Satisfactory
182	Nodule-Bacter	Bean	S	S	S	Satisfactory
184	Nodule-Bacter	Pea	U	U	U	Unsatisfactory
		Bean		I	I	Inconclusive
		Lima bean		U	U	Unsatisfactory
195	Nodule-Bacter	Pea	S	S	S	Satisfactory
		Bean		S	S	Satisfactory
		Lima bean		U	S	Satisfactory

TABLE I — RESULTS OF LEGUME CULTURE TESTS, 1934 — *(Concluded)*

Sample number	Brand	Group	Bacterial count *	Nodule Formation †		Conclusions
				With 1/10 the recommended inoculum	With the recommended inoculum	
132	Stimugerm	Alfalfa	S	S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
141	Stimugerm	Alfalfa	S	S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
145	Stimugerm	Alfalfa	S	S	S	Satisfactory
		Sweet clover		S	S	Satisfactory
140	Stimugerm	Red clover	P	U	S	Satisfactory
		Alsike clover		S	S	Satisfactory
198	Stimugerm	Red clover	S	S	S	Satisfactory
		Alsike clover		S	S	Satisfactory
142	Stimugerm	Pea	P	S	S	Satisfactory
146	Stimugerm	Pea	S	S	S	Satisfactory
133	Stimugerm	Soybean	S	S	S	Satisfactory
143	Stimugerm	Soybean	S	S	S	Satisfactory
147	Stimugerm	Soybean	S	S	S	Satisfactory
130	Stimugerm	Pea	P	I	U	Unsatisfactory
		Bean		I	S	Unsatisfactory
131	Stimugerm	Pea	P	I	S	Satisfactory
		Bean		I	S	Satisfactory
134a	McQueen's	Pea		U	S	Satisfactory
		Bean		S	S	Satisfactory
		Lupine		U	S	Satisfactory
134b	McQueen's	Pea		U	S	Satisfactory
		Bean		S	S	Satisfactory
		Lupine		U	S	Satisfactory
164	Strasburger & Siegel	Pea	U	U	S	Satisfactory
165	Strasburger & Siegel	Pea	U	U	U	Unsatisfactory
159	Berry's	Alfalfa		U	S	Satisfactory
		Sweet clover		S	S	Satisfactory

* Bacterial counts were made on pure cultures only; this explains the blank spaces in this column. The letter S (satisfactory) indicates that per pound of seed the culture contained over eight million organisms which were apparently root nodule bacteria, P (poor) that the count was between one and eight milljons, and U (unsatisfactory) that less than one million were present per pound of seed.

† S = Satisfactory
U = Unsatisfactory
I = Inconclusive

‡ These cultures were made by a new process.

Circular No. 137 (Revised)

Perry W. Wilson

New York State Agricultural Experiment Station

Geneva, N. Y.

SOIL INOCULANT SERVICE

In 1930, a law was adopted by the State of New York instructing Station to test for the Department of Agriculture and Markets ples of soil or plant inoculants sold or offered for sale in the te. Up to the present time these inoculants, with one exception,

FIG. 1.—THE STATION GREENHOUSES.
One of these houses is devoted to the testing of legume inoculants.

been cultures of bacteria intended for the inoculation of legume The Station has, accordingly, undertaken the work of testing e cultures, and the results of the tests are published at Albany lletins of the Department.

The official samples of legume inoculants are purchased by an pector of the Department of Agriculture and Markets at stores or ewhere they are offered for sale to the public. Tests are then e in the Station laboratories and greenhouses, to determine the bility of the cultures and to show whether the claims made by nufacturers are in any way misleading.

o far only one case has been found where the culture to be ered for sale was so obviously worthless that the Department of

Agriculture and Markets refused to permit registration. In this instance, the culture was a foul-smelling liquid offered for sale in an attractive-looking tin can. The manufacturers made claims as to its ability to inoculate not only legumes but almost any other kind of crop and to stimulate plants to reach maturity in a short period of time. The culture contained many bacteria, to be sure, as would a similar canful of liquid manure or any other decomposing liquid; but tests made at the Station failed to show justification for the manufacturer's claims. Accordingly, permission to register this product for sale in New York was refused and as a result there will be no high-pressure campaign to sell this material to farmers of this State.

The work of 1931, the first year that these tests were conducted, showed, however, that there were also a number of inferior legume inoculants on the New York market. It became apparent when tests were made that some of the cultures which sold in largest quantities were among the poorest on the market. In one instance, the company was a reliable concern which had been in business for many years but had specialized in the selling of other products. At a meeting of their representatives and Station workers, improvements were suggested. These have since been made, and the cultures produced by this company performed satisfactorily in the 1933 tests.

The other inferior samples were from a company which also is careful to maintain high standards. Studies have been made at this Station with the intention of finding what point in the process of manufacture needs to be corrected to bring all of this company's cultures to the proper level of quality. It is expected that the changes necessary to bring this about will be made shortly, so that the 1934 product will undoubtedly be of good quality.

Usually, the inferiority of cultures is due to unsatisfactory methods of production, but in other cases it occurs because the products are kept too long by the retailer before sale.

In general, three methods of improving the situation are available, namely, (1) refusal by the Department of Agriculture and Markets to register cultures for which entirely unreasonable claims are made, (2) securing the cooperation of manufacturers in improving their methods and in withdrawing old cultures from the market; and (3) educating farmers as to the greater value of fresh cultures. Usually the second method is best, but it is still necessary that farmers exer-

cise care to buy only such cultures that have not passed their date of expiration.

In addition to these activities, the Station has been carrying on experiments endeavoring to improve and to shorten the prevailing methods for testing legume cultures. Since the inoculants consist of tiny living germs, rapid chemical tests cannot be used to determine their identity and their numbers. The only reliable method at present available is the use of the culture with the plants for which it is recommended. This requires carefully controlled greenhouse experiments in which the culture is used to inoculate sterilized seeds growing in sterilized sand. Even this method has its drawbacks, as will be appreciated when it is understood that a gust of wind blowing a little dust from a properly inoculated pot to one in which an ineffective culture is being tested may spoil the results of the latter experiment. Improved methods are desired, both for greater reliability and greater speed. Definite progress in both respects has already been made, and as a result, further improvement and simplification is expected.

In these ways the Station is assisting the farmer in his efforts to purchase reliable inoculants for seed treatment. It is desired to enable him to purchase the cultures on their merits without danger of confusion by the advertising claims of the manufacturer. If he is misled by these claims and pays money for a worthless culture, he loses not only the small sum he pays for the inoculant, but also the much larger sum which he will lose from failing to get the expected improvement in his crops. This might show itself only in a slightly lowered yield, or it might consist in the loss of practically the entire crop; on some land, indeed, inoculation of a legume spells the difference between success and failure. In such cases, legume inoculation is cheap insurance against loss of seed, labor, and harvest; and to the individual farmer who follows this practice, a reliable inoculant is an absolute necessity.

At the present time, it is gratifying to be able to say that the situation with regard to legume inoculants has improved materially in this State. Whereas, in 1931 and 1932, the tests showed that a high proportion of the cultures were unsatisfactory, in 1933 they indicated a much smaller percentage as inferior. This last year the poor products were often found to be mixed cultures sold in small containers, recommended for garden purposes. Those intended for

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the inoculation of soybeans were also of low quality. Further tests are necessary to determine the seriousness of the situation and to learn what measures should be taken to correct it.

Close attention is always given to any new cultures that may be placed on sale in the State, that they be of such quality as to inoculate the plants for which they are recommended. Both seed dealers and farmers would do well to bear in mind, however, that the official inspection of legume inoculants applies only to cultures offered for sale within the State and not to cultures purchased outside its limits. For full protection of the law, therefore, the buyer should make his purchases of legume inoculants within the borders of New York. The results of the tests made in 1933 are published in the Agricultural Bulletin of the Department of Agriculture and Markets. Seed dealers can easily secure information from this source as to the reliability of the various brands. Farmers will perhaps find it advantageous to obtain information concerning cultures directly from the Station or the local Farm Bureau agent.

The names of cultures which have been tested and found reliable for field crops are as follows: G. L. F., Nitragin, Nodule-Bacter, Urbana Culture, Nod-O-Gen, Strasburger and Siegel, Scott's and Stimugerm. In the future, additional changes will be made in the approved list as new names are added or old ones dropped. Further information regarding inoculants or the provisions of the law may be obtained upon request to this Station.

January 1, 1934

H. J. CONN and A. W. HOFER

1078 DEFENDANT'S EXHIBIT 34.

390

DEPARTMENT OF COMMERCE

United States Patent Office

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the records of this office of the File and Contents, in the matter of the

Letters Patent of

Varley Sherman Bond, assignor to Kalo Inoculant Company,

Number 2,200,532, Granted May 14, 1940,

for

Improvement in Bacterial Inoculants for Leguminous Plants.

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this twenty-sixth day of May, in the year of our Lord one thousand nine hundred and forty-five and of the Independence of the United States of America the one hundred and sixty-ninth.

ATTEST:

D. E. WILSON
Chief of Division.

CONWAY P. COE,
Commissioner of Patents.

(Seal)

1079

NUMBER (Series of 1935) 226565 PATENT NO. 2200532

1938

Dated May 14, 1940

Div. 59 (Ex'r's Book) 121-9-071

Name VARLEY SHERMAN BOND,

Assor to Kalo Inoculant Company, of Quincy, Ill., a Corp. of Illinois.

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of QUINCY, State of ILLINOIS.

Invention BACTERIAL INOCULANT FOR LEGUMINOUS PLANTS

Parts of Application Filed

ORIGINAL	RENEWED
Application Filed Complete Aug. 24, 1938	.....
Petition, Specification, Oath, First Fee $30, } Aug. 24, 1938	.....
1 sheets Drawings,	.....
1 " Drgs. Mar. 11, 1940	.....
.....	.....
.....	.....
Examined and passed for Issue Apr. 1, 1940. P. W. Shepard Exr. Div. 59	Reexam'd and passed for Issue....., 193 Exr. Div.
Notice of Allowance Apr. 1, 1940.	....Notice of Allowance ....., 193
By Commissioner	By Commissioner
Final Fee $30 Apr. 13, 1940	Final Fee....., 193

Division of App. No. filed 19....

Attorney AMES, THIESS, OLSON & MECKLENBURGER, 77 West Washington St., Chicago, Ill.

Associate Attorney .....

.....

No. of Claims Allowed 14 Print Claims 1 & 10 in O.G. Class 71-7

Title as allowed Bacterial Inoculant for Leguminous Plants.

.....

1080

PETITION.

Aug.-24-38 037479 H Check 30.00

To the Commissioner of Patents:

Your Petitioner, Varley Sherman Bond, citizen of the United States, and a resident of Quincy in the County of Adams and State of Illinois, whose Post Office address is 1422 Maine Street, Quincy, Illinois, prays that letters patent may be granted him for the improvements in Bacterial Inoculant for Leguminous Plants set forth in the annexed specification.

And he hereby appoints the firm of AMES, THIESS, OLSON & MECKLENBURGER, consisting of Robert Lewis Ames, J. Bernhard Thiess, A. F. Mecklenburger, Arthur A. Olson, Willard L. Pollard, George W. Hansen, A. Arnold Brand, Thorley von Holst, Bertram Wm. Coltman, Albert H. Pendleton, and Carl Marx, 77 West Washington Street, Chicago, Illinois, his attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

Signed at Quincy in the County of Adams and State of Illinois, this 20th day of August, 1938.

Reg. No. 9622.

Varley Sherman Bond

(Inventor sign here, including first name in full)

TO ALL WHOM IT MAY CONCERN:

Be it known that I, Varley Sherman Bond a citizen of the United States, residing at Quincy in the County of Adams and State of Illinois, have invented new and useful improvements in BACTERIAL INOCULANT FOR LEGUMINOUS PLANTS, of which the following is a full, clear, concise and exact description, reference being had to the accompanying drawing forming a part of this specification.

1081 This invention relates to a bacterial culture and more specifically to a bacterial culture useful for the inoculation of the seeds of leguminous plants.

It is well known that certain plant species of the genus Leguminosae may under certain conditions fix nitrogen directly from the air and convert it to organic nitrogenous compounds. The mechanism of this nitrogen fixation is not understood at the present time, but it has been known for a number of years that it can only be carried out when the plant grows in symbiotic relationship with certain bacteria of the genus Rhizobia. Plants belonging to the genus Leguminosae which are capable of symbiotic relationships with the Rhizobia are peas, beans, alfalfa, red clover, white clover, vetch, lupines, and the like. The bacteria infect the roots of these plants in the soil and cause the formation of so-called nodules,

in which it is presumed that the nitrogen fixation in the plant occurs.

Other plants that are important in agriculture, such as the grasses and grains, are not able to fix nitrogen from the air. They depend entirely upon the combined nitrogen in the soil, such as nitrates and ammonium salts, for their nitrogen requirements. Consequently, the combined nitrogen in the soil becomes depleted after a series of crops consisting only of the non-nitrogen fixers have been grown therein. It has consequently become customary in many districts to practice crop rotation, whereby the plants that are capable of fixing nitrogen in the soil will enrich the soil with combined nitrogen, whereby nitrogenous nutrients are provided for a succeeding crop of non-nitrogen fixing plants. More recently it has become the practice to plant mixed crops, which comprise a mixture of the nitrogen fixing and the non-nitrogen fixing variety. Nitrogen is thus supplied to the soil in a combined form which may be readily utilized by the non-nitrogen fixing plants.

1082

Bacteria of the genus Rhizobia which are capable of infecting leguminous plants so that nitrogen may be fixed are widely spread in nature. They are not, however, universally present in soil and it has been found desirable to inoculate the seeds of leguminous plants with a culture of bacteria of the genus Rhizobia previous to the planting of the seeds in the field. This inoculation insures that micro-organisms of the correct species will be present in the soil whereby the leguminous plant may become infected. In the absence of such infection as pointed out above, no nitrogen fixation occurs within the plant. The inoculation of seeds is particularly desirable where it is desired to plant them in a soil that has not grown a plant of the same species for a number of years. In order to insure a maximum amount of nitrogen fixation and development of the leguminous plant, it is always desirable to inoculate the seeds previous to the planting thereof.

Figure 1 shows a root portion of a red clover plant bearing nodules A which were produced by infection with Rhizobium trifolii. This view was taken with

permission of the authors from a photograph reproduced in the monograph Root Nodule Bacteria and Leguminous Plants, by Fred, Baldwin and McCoy, University of Wisconsin Studies in Science, No. 5, 1932.

Fig. 2 shows a group of forty red clover plants after ten weeks' development in a sterile nitrogen-free sand culture which was not inoculated previous to the time of planting.

Fig. 3 shows a group of forty-one red clover plants of the same age and number grown in the same nitrogen-free substrata as those in Fig. 2, but wherein the seeds were inoculated with a culture of Rhizobium trifolii previous to planting.

Fig. 4 is the same as Fig. 3 but wherein the seeds were inoculated with a composite culture prepared in accordance with one embodiment of this invention.

It was discovered early that all species of the genus Rhizobia would not infect all of the plants of the genus Leguminosae to produce nodules wherein the nitrogen fixation presumably takes place. Thus certain species of bacteria are specific to certain species of Leguminosae. The group of plants that will be infected by a single species of bacteria has come to be known in the art as a cross-inoculation group. There are at least six well-recognized species of Rhizobium which will infect six fairly well-defined cross-inoculation groups of plants. Rhizobium meliloti will infect alfalfa and white or yellow sweet clovers; Rhizobium trifolii will infect red, white, crimson or mammoth clovers; Rhizobium leguminosarum will infect garden or field peas, vetch, and broad beans; Rhizobium phaseoli will infect garden or field beans; Rhizobium lupini will infect the lupines; and Rhizobium japonicum will infect the soy beans. The above groups are the most important in regard to inoculation of the seeds of field crops previous to sowing. There is a mixed group, including cow peas, lespedeza, peanuts, velvet beans, lima beans and crotalaria, which has not been well enough defined with respect to cross-inoculation to be assigned a definite terminology. This latter group, however, have been relatively unimportant for the

preparation of commercial bacterial inoculants for the seeds of leguminous plants.

A number of so-called commercial cultures of bacteria have appeared on the market from time to time which were purported to be useful for producing nodulation of the roots of the leguminous
1084 plants. Many of these cultures have been very effective and useful for the purpose for which they were to be employed. These cultures have appeared in a large variety of forms and contain a large number of viable strains of the desired organism. They have been distributed on suitable jelly bottle slants or in a wet or dry carrying material such as sand, soil, or charcoal.

A variety of methods have also been employed for producing the bacterial inoculant for commercial distribution. In the preparation of an inoculant or culture in accordance with one method the carrying media, such as humus or charcoal, may be inoculated with a suitable strain of the organism, and sugar, mineral salts, and water may be added with subsequent development of the species of organism therein. The resulting material is then packaged and distributed in any desired manner. This is known as the simple humus culture, but is not entirely satisfactory since it is usually desirable to at least partially sterilize the humus or other carrying material previous to inoculation with the Rhizobia culture in order to insure that the distributed organism will develop within the material to such an extent that a suitable number of organisms would be produced sufficient to inoculate the seeds to be treated. Furthermore, a large amount of metabolic products of the organisms were formed directly in the culture, which do not provide a healthy environment for the organisms, and a large percentage have a tendency to die off in a relatively short time.

A second method that has been employed for the preparation of commercial inoculants has been to develop the organism in a liquid culture and, after the development of the organism in the liquid, mix the
1085 liquid with the desired amount of carrying material such as humus or charcoal. This method again has the disadvantage that the metabolic products of

the organism and the residual sugars and protein of the culture medium are introduced directly into the commercial product as distributed, which tends to cause deterioration of the culture and the death of a large proportion of the organisms contained therein.

All of the cultures that have been successfully used in the past for the inoculation of the field leguminous plants, such as clover, alfalfa, soy beans, and the like, have contained only one species of the organism. Thus, for inoculation of soy beans, it has been the practice to use a bacterial inoculant comprising substantially a pure culture of Rhizobium japonicum in order to obtain maximum plant yield and maximum nitrogen fixation. The same is true with respect to the inoculation of the seeds of the plants belonging to the various other cross-inoculation groups which have been indicated above.

It has heretofore been considered impracticable to prepare a composite culture inoculant containing organisms which will cause nodulation on more than one of the cross-inoculation groups. This has not been done because it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented. For this reason it has been considered desirable to use a culture containing a single species of organism rather than one containing a mixture.

The use of a single species of bacteria in a culture presents a serious difficulty in the manufacture and distribution of bacterial inoculants, since it is therefore necessary to distribute a separate culture contained in a separate package for the inoculation 1086 of seeds of plants belonging to the various cross-inoculation groups. This situation is further complicated by the fact that the cultures as distributed are ordinarily usable for only a certain length of time after preparation, since the organisms in the culture tend to die out on storage of the culture on the shelves of the distributor. It has consequently become the practice among the distributors of bacterial inoculants of this character to replace cul-

tures free of charge that are unused and over about one year old.

At the present time there are on the market many so-called "pasture mixtures" of seeds which comprise a mixture of seeds including those of different species of leguminous plants. These are distributed in comparatively small quantities, and heretofore the farmer seldom takes the trouble to inoculate the mixture with the several separate bacterial cultures necessary for the seeds of each cross-inoculation group in the pasture mixture.

One object of this invention is to provide a method for the preparation of an inoculant for the seeds of leguminous plants which will contain a large number of micro-organisms and will retain their viability over a long period of time.

A further object of this invention is to provide a method for introducing a culture of bacteria into a suitable carrying material within which the inoculant is distributed.

A further object of this invention is to provide a mixed culture of Rhizobia capable of inoculating the seeds of plants belonging to several cross-inoculation groups and having the same efficiency in respect to nitrogen fixation as a culture which contains only a single species of the organism.

A further object of this invention is to provide a mixed culture the component strains of which are 1087 selected in such a manner that optimum efficiency results when the organisms are combined into a single culture.

A still further object of this invention is the provision of a bacterial culture prepared in admixture with a fine powdered inert material in a new and novel manner.

A further object of this invention is to provide an inoculant for the so-called "pasture mixture" which comprises efficient nitrogen fixing strains of different species of Rhizobia combined in one culture.

Further and additional objects of this invention will appear from the following detailed description, the drawings, and the appended claims.—

In order to prepare an inoculant in accordance with one embodiment of this invention, the desired

species of organism may be inoculated in any desired manner onto the surface of a suitable agar or jelly culture medium and allowed to grow for a period of several days. A quantity of water may then be added with thorough shaking and further growth permitted, after which time the resulting suspension may be incorporated with a suitable carrying medium such as humus, charcoal, soil, fine sand, and the like. The bacterial inoculant prepared in accordance with this general method contains an enormous number of organisms which will remain viable over a long period of time. The inoculant is easily handled and may be readily packed in cans or other containers for distribution to the farmer. If the carrying material employed is black humus or charcoal, the inoculant has a further advantage in that it may be readily determined whether or not it has been thoroughly mixed with the seeds previous to inoculation.

In order that this invention may be more readily 1088 understood, a specific example is presented in order to more definitely point out the method of preparation of the inoculant. A suitable and preferably pure culture of a bacterial species is selected. It may be obtained by direct isolation from the nodules of a leguminous plant according to methods that are well known in the art. Suitable methods are described by Fred, Baldwin and McCoy, supra, and in the Laboratory Manual of General Microbiology, by Fred and Waksman, 1928. The organism may be cultivated on a yeast extract-sucrose agar which may contain the following ingredients:

Agar	grams	15.0
Sucrose	do	10.0
Dipotassium phosphate	do	0.5
Magnesium sulfate	do	0.2
Sodium chloride	do	0.1
Calcium carbonate	do	1.0
Calcium gluconate	do	1.5
Yeast Water (pH 6.8)	cc.	50
Tap water	do	950

The yeast water infusion in the above formula may be prepared as suggested by Fred and Waksman, supra, page 16, as follows: Two kilograms of fresh

starch-free pressed yeast are added to 10 liters of tap water. The mixture is steamed for three to four hours at 95° to 100° C. with occasional stirring. The resulting mass is sterilized in an autoclave in deep layers for a period of about one hour. The sterilized material is allowed to stand for about one week, and, if undisturbed, the yeast cells will settle to the bottom and leave a clear straw-colored liquid above. The clear infusion may then be siphoned off and the reaction adjusted to pH 6.8 to 7.0. This clear infusion is the yeast water referred to in the above formula.

The ingredients of the medium are mixed together and sterilized in the usual manner. The calcium carbonate may be sterilized separately and added to the sterile medium after it has cooled down in order to prevent the decomposition of sucrose during the heating period. The medium prepared in accordance with the formula given above is a jelly on the surface of which cultures of the Rhizobia may readily develop under aerobic conditions. It may be also prepared in the liquid form by eliminating the agar.

The desired culture of the Rhizobia may be inoculated onto an agar slant of the medium and incubated at suitable temperatures for a time to permit development of the culture on the surface of the agar. This first transfer of the culture is generally made in test tubes. After a suitable period of incubation, the culture may then be transferred by a sterile needle or loop from the test tubes to an agar slant in a 200 cc. flat bottle containing about 30 cc. of slanted agar media. Here the organism is again permitted to develop for a suitable incubation period at 28° to 30° C., which in most cases will extend from a few days to over a week. The culture grown on the agar surface of the bottle may then be aseptically washed from the surface with sterile water according to recognized bacteriological technique whereby a suspension of the organisms is produced. This suspension, being quite heavy and almost opaque, may be used for the inoculation of slanted agar media contained in a plurality of still larger bottles such as one liter bottles. These bottles may contain about 125 cc. of the agar medium described above. The inoculation may be made by streaking with a needle or

aseptically spraying a water suspension of the organisms onto the surface of the agar by an atomizer or any suitable spraying means. It is desirable that aseptic conditions be maintained throughout the process until after the large bottles have been inoculated with a pure culture of the organism. Prevention of contamination up to this point is desirable, since the contaminating organism may outgrow the desired species of the Rhizobia, thus negativing the effect of the culture for seed inoculation purposes.

After the culture has developed on the surface of the agar in the large bottles for a suitable length of time (from about 2 to 10 days), tap water may be added in order to fill the bottles about half full. They are thoroughly agitated and the agar is cut or broken with a suitable metal probe, whereby the bacteria are rinsed from the surface of the agar and the agar becomes thoroughly broken up in the bottom of the bottle. It may be desirable, but it is not necessary, to employ sterile water for this purpose. The growth of the Rhizobia has taken place to such an extent that any chance contaminant will readily be suppressed by the large numbers of the Rhizobia.

After the agar has been thoroughly broken up, the large bottles are allowed to further incubate at suitable temperatures for a period of a few days. It has been found that the number of the organisms becomes very greatly increased during this subsequent period of incubation. The agar may then be separated from the suspension of organisms by passing the suspension through a suitable filter or screen. A four mesh screen has been found to be satisfactory. The bottles and agar may be washed with a small quantity of tap water. The resulting filtered suspension of bacteria is very heavy, being milk-like in appearance. This suspension may then be thoroughly incorporated with any desired amount of humus, which serves as a carrying means for the organism of the suspension. The humus and suspension mixture is allowed to stand for about 12 to 24 hours before the material is packed in order to permit complete absorption of the moisture by the humus. The resulting composition may then be packaged in moisture-proof fiber cans or other suitable containers for shipment.

The material from seventy-two one liter bottles inoculated and treated as described above is sufficient to inoculate about ninety kilograms of humus in order that the concentration of organisms in the humus will be approximately sixty million per gram. The final product may contain about 45% moisture. The water content may be adjusted by adding water in the desired proportions previous to packaging.

It will be understood, of course, that other types of media may be employed for the development of the organisms preliminary to its inoculation into the humus or other carrying material, and the proportions of the various ingredients may be varied within a wide latitude. Likewise, charcoal, fine sand, soil, kieselguhr, and other materials may also be used as the carrying medium. If humus is employed, it may be desirable to neutralize its natural acidity with hydrated lime or calcium carbonate. It is not necessary, as has been previously stated, that sterile conditions be maintained after the incubation period on the surface of the agar immediately preliminary to the addition of the excess water. Sterile conditions are not necessary after this point, since the organisms have increased to such large numbers that they will suppress any type of contaminating organism that may be introduced. Likewise, it is not necessary to sterilize the humus or other carrying material because of the tremendous number of organisms of the desired type that are introduced therein. It will be readily recognized, however, that, if desired, strict aseptic conditions may be maintained up until the time the material is packaged in the containers for shipment.

The culture prepared in accordance with this method contains a sufficient number of organisms so
1092 that 150 grams will inoculate about one bushel of small seed.

It will be understood from the above description that the number of organisms incorporated into the humus may be readily predetermined by means of a Petroff-Hausser bacterial counter or other suitable direct counting apparatus. This method, therefore, has the advantage that the number of organisms being introduced into the final inoculant may be readily

determined. The final culture is also comparatively free of excess sugar and minerals, since they are retained to a large extent by the agar in the large bottles. Consequently, additional nutrient is not introduced into the humus which may stimulate the development of contaminating organisms.

It will be understood also that the incubation period at the different stages of preparation of the culture previous to inoculating into the carrying means depends on many factors recognized by one skilled in the art. Thus, the character of the media, the temperature of incubation, and the species of Rhizobium are factors to be considered.

In order to inoculate the seeds of leguminous plants by the inoculant prepared in accordance with the above given description, the seed, within about twenty-four hours previous to the time of planting, is slightly moistened and a predetermined quantity of the inoculant is thoroughly mixed therewith in order to provide the desired concentration of organisms on the seed. The distribution of the inoculant throughout the seeds may be readily observed because of the black color of the humus with which the inoculant is prepared. The inoculant prepared in accordance with this invention may be satisfactorily used for a period of more than one year and sufficient organisms remain viable during this time in order to provide a number satisfactory for thorough inoculation.

1093 As has been pointed out above, composite cultures for inoculating the seeds of leguminous plants have not generally come into use because of the inhibitory effect that certain strains of certain species of the Rhizobia have on each other and also because no method has been developed whereby a composite culture may be produced wherein a sufficient number of each species of organism in the inoculant is insured.

In order to more clearly point out the nature and magnitude of the inhibitory effect of several species of Rhizobia, tests were carried out using strains of various organisms which were picked at random and unselected in the manner to be hereinafter described. Thus a culture of Rhizobium japonicum which was known to be an efficient culture for fixing nitrogen

when in association with the soybean plant was tested in order to determine its nitrogen fixing efficiency when inoculated onto soybean seeds in the presence of Rhizobium trifolii and Rhizobium meliloti. The tests were made by growing the appropriate plants in sterilized nitrogen-free sand according to well known methods in the art and fully set forth by Fred and Waksman, supra, and Fred, Baldwin and McCoy, supra. Three groups of soybean plants containing eight plants in each group were planted in a nitrogen-free sand containing suitable mineral salts and according to the standard methods. One group of seeds were planted sterile, being uninoculated. The seeds of the second group were inoculated with a single strain of the species of Rhizobium japonicum indicated above. The third group of seeds was inoculated with a mixture of the same strain of Rhizobium japonicum and strains of Rhizobium trifolii and Rhizobium meliloti. The seeds were permitted to germinate and the plants were grown in the sand for a period of fifty-six days. The eight plants developing from each group were then analyzed for total nitrogen by a suitable Kjeldahl procedure. The plants of the first group (uninoculated) contained a total of 79 milligrams of nitrogen. The plants of the second group (single strain) contained 246 milligrams of nitrogen. The plants of the third group (same strain mixed with strains of other species) contained only 203 milligrams of nitrogen. Consequently the plants of the second group fixed 167 milligrams of nitrogen over the control, and the plants of the third group only fixed 124 milligrams of nitrogen over the control. Thus it will be seen that this strain of Rhizobium japonicum produced 34.8% more nitrogen when employed alone than when employed in the presence of strains of other species of Rhizobia.

In the same manner a strain of Rhizobium trifolii which efficiently fixed nitrogen in the presence of the host plant alone was tested. Groups of forty plants were inoculated in this instance in the manner indicated above which is well recognized in the art. It was found that this unselected strain of Rhizobium trifolii caused about 118% more nitrogen to be fixed in the host plant when employed alone as an inocu-

lant than when in the presence of other species of the Rhizobia, such as Rhibozium japonicum and Rhizobium meliloti.

It is possible, in accordance with one embodiment of this invention, to produce an effective composite inoculant containing a plurality of species of organisms which is capable of infecting a variety of leguminous plants belonging to a plurality of cross-inoculation groups.

In general, the composite culture may be prepared by selecting strains of the desired species of the Rhizobia which will produce optimum beneficial results to the host plant and will not be adversely affected by each other. The strains, after having been selected, may be cultivated in a manner which has been described above on agar or jelly media separately, the heavy suspension of each organism being introduced directly into the humus or other carrying material in the manner that has been previously described.

In order to produce a composite inoculant containing, for example, Rhizobium meliloti, Rhizobium trifolii, and Rhizobium japonicum, which inoculant will infect the corresponding cross-inoculation groups, a number of strains of each of these organisms may be isolated from nature by any of the approved methods such as have been described in the above referred to Laboratory Manual of General Microbiology by Fred and Waksman. Each of the strains are tested separately with its own host plant in order to select out those which are most effective in respect to the development of the host plant and the quantity of nitrogen fixed thereby. These tests may be made according to standard practice by aseptically growing the plants in a nitrogen-free substrata such as sand containing mineral salts. The cultures showing the best results in association with the host plant may then be selected and the various strains of the different species may be mixed together in order to determine if the nitrogen-fixing ability of one species is adversely affected by the mere presence of another, as has been previously thought to be the case. Thus, it has been previously considered that the nitrogen-fixing ability of Rhizobium trifolii in symbiotic rela-

tionship with red clover is markedly inhibited if strains of Rhizobium meliloti, Rhizobium japonicum, or other species of the Rhizobia were present within the same inoculant. It has been found, however, that, by a suitable process of selection of strains in the manner indicated above, a composite culture may be obtained which may be used to infect a plurality of cross-inoculation groups with optimum results.

The organisms of the genus Rhizobium which are mutually noninhibitive may be designated by the term alpha. No method has been observed whereby the alpha strains of the organisms may be differentiated from the mutually inhibitive group of Rhizobia other than by making actual nitrogen fixation tests by inoculating the various host plants with the proposed mixture of the Rhizobia. A composite culture that is satisfactory for use for inoculating seeds of alfalfa, red clover, and/or soy beans (representatives of three cross-inoculation groups) contains a mixture of Rhizobium meliloti alpha, Rhizobium trifolii alpha, and Rhizobium japonicum alpha. All of the strains may be selected so as to be mutually noninhibitive when mixed and used for seed inoculation. It will, of course, be recognized that certain inhibitive strains may be employed in the mixture. In general, however, it is desirable to use the alpha strains which have been selected in the manner proposed in the above. By the alpha strains, which have been designated herein, is meant those strains of the species of Rhizobia which are mutually noninhibitive of each other as regards nitrogen fixation in the host plant. It is understood that the alpha strains of each species may vary somewhat from each other in minor physiological, morphological and/or immunological characteristics. All such variants may be included within the scope of the term alpha strain.

One criterion by which the alpha strains of the organisms may be determined is based on a statistical comparison of the total milligrams of nitrogen fixed in plants previously inoculated with a single strain unmixed with strains of other species with the total milligrams fixed in plants inoculated with the same strain mixed with strains of other species. In mak-

ing such tests the conditions for inoculation and growth of the plants should be kept uniform when testing both the mixed culture and the single strain. The method for carrying out tests for determining the amount of nitrogen fixed by leguminous plants in association with the various species of the Rhizobia are well known in the art and are given in detail by Fred and Waksman, supra, and Fred, Baldwin and McCoy, supra.

Each culture may be tested by inoculating a given number of seeds of the proper host plant with a strain of culture of bacteria to be tested either singly or mixed with other species of the Rhizobia. The seeds may then be planted in jars containing sterile sand and appropriate nitrogen-free mineral salt solutions capable of supporting plant growth. The same number of seeds are planted in each of five jars for each culture being tested, and the total number of milligrams of nitrogen fixed by the plants in each of the five jars is tested. The standard deviation of the mean amount of nitrogen fixed in each jar may then be determined by appropriate statistical methods. If the mean plus or minus the standard deviation of the nitrogen content of plants inoculated with a strain used unmixed with the strains of another species, overlaps the mean plus or minus the standard deviation of plants inoculated with the same strain used mixed with other species of Rhizobia, that strain may be considered as nonantagonistic or an alpha strain within the meaning of this invention.

For the preparation of a composite bacterial inoculant in accordance with this invention, heavy suspensions of selected cultures of Rhizobium trifolii alpha, Rhizobium meliloti alpha, and Rhizobium japonicum alpha may be prepared in the same manner as has been indicated above for the preparation of a single culture in accordance with this invention. The heavy suspensions may then be mixed and introduced into the humus in concentrations suitable to give the desired results.

In order that 90 kilograms of dry humus may be properly inoculated with the three organisms indicated above, about [19]* liters are prepared of each suspension in the manner previously indicated. The

* Matter in brackets inserted.

concentration of organisms in the suspension may be about [300]* million per cubic centimeter for Rhizobium meliloti alpha and Rhizobium trifolii alpha and about [450] million per cubic centimeter for Rhizobium japonicum alpha. The suspensions may be introduced into the humus or other carrying material separately or may be mixed before introduction. The humus, after inoculation with the three organisms (about [57] liters of composite suspension), may be passed through a suitable mechanical mixer in order to thoroughly incorporate the organisms within the humus or carrying material. The water content of the humus may be brought up to about 45% and the mass is permitted to stand for about 12 to 24 hours preliminary to packaging in order to permit a more thorough absorption of the water and bacterial cultures into the humus. This latter storage period also causes the humus to become lighter and more easily handled by the packing machines, which may be of any desired kind. One hundred seventy-five grams of this inoculant is sufficient to inoculate one bushel of red clover or alfalfa seed or two bushels of soy bean seed.

The resulting composite inoculant may be used for inoculating the seeds of leguminous plants in the same manner as hereinbefore set forth. It may be used with good results for inoculating the seeds of any of the plants included within the cross-inoculation groups represented by the bacterial species present. The particular example given has included Rhizobium trifolii alpha, since it has been generally thought that Rhizobium trifolii was particularly sensitive to other of the Rhizobia in respect to its ability to fix nitrogen within the host plant. It has been found, however, that, by suitable selecting, strains of the organism may be found from which a composite inoculant may be produced having all of the desirable qualities of a single strain culture with the further additional advantages previously indicated.

It will be understood that this invention is not to be limited to the above described method for producing a composite inoculant. It is not necessary that it be prepared as set forth in the manner described above. Any inoculant comprising a mixture of se-

* Matter in brackets inserted.

lected anti-inhibitive strains of ordinarily inhibitive organisms of the Rhizobia group is included within the spirit and scope of this invention.

In order that a more definite understanding may be had of the advantages to be derived from the use of a composite culture selected and prepared in accordance with this invention, a series of tests were made by planting red clover seeds in half gallon jars containing sterile sand supplemented with all essential minerals except nitrogen, and were inoculated as indicated below. After ten weeks of growth in the greenhouse under identical conditions, the sand was washed from the roots of the plants, the plants dried, weighed and ground and samples were analyzed by the Kjeldahl method for their nitrogen content.

Each group or series of seeds was planted in a series of five jars and the standard deviation between the jars of each culture series was determined. Each series was inoculated as follows:

1. Uninoculated control plants.
2. Plants inoculated with a non-selected strain of Rhizobium trifolii in single culture unmixed with other species.
3. Plants inoculated with a selected, non-antagonistic strain of Rhizobium trifolii alpha in single culture unmixed with other species.
4. Plants inoculated with same organism as series 2 in admixture with other species of the Rhizobia.
5. Plants inoculated with the same organism as series 3 in admixture with other species of Rhizobia.

The following table is presented which indicates the inoculant used for each series of plants, the dry weight of ten plants, the per cent of nitrogen in the dry material, the milligrams of nitrogen present per ten plants, and the milligrams of nitrogen fixed per ten plants:

Inoculant Series No.	Grams Dry Wt. Per 10 Plants	% Nitrogen	Mg. Nitrogen Per 10 Plants	Mg. Nitrogen Fixed Per 10 Plants
1	0.61	1.07	6.5 ± 0.8*	.....
2	4.18	2.92	122.0 ± 10.8*	115.5 ± 10.0*
3	4.60	2.85	131.0 ± 16.6*	124.5 ± 15.8*
4	3.53	2.29	80.8 ± 4.7*	72.3 ± 3.9*
5	4.50	2.83	126.0 ± 40.5*	119.5 ± 39.7*

* Standard deviation of the mean of a series of 5 jars.

It will be observed that the nitrogen fixing efficiency of the inoculants of series 2, 3 and 5 are high and substantially the same. When the non-selected strain, however, was mixed with other species of the Rhizobia the amount of nitrogen fixed by the host plant was seriously impaired as indicated by series 4. This example clearly shows the increase in effectiveness of a mixed culture which contains an alpha strain over that which contains a non-selected but otherwise efficiently nitrogen fixing strain. It is pointed out here that the mean plus or minus the standard deviation of the nitrogen fixed by series 4 does not fall in the same range as the mean plus or minus the standard deviation of that fixed by series 2. Series 3 and 5 do overlap in this respect and the strain of Rhizobium trifolii employed in those tests was consequently an alpha strain according to the one criterion that has been previously described.

It is to be understood that this invention is not to be limited to the selection of a single strain which is to be used in the composite culture. All of the strains may be selected in the manner indicated previous to the preparation of the inoculant. Furthermore, if desired, a plurality of strains of the same species may be introduced into the composite culture containing several species. This practice has been found to be desirable in many instances in order that there will be double insurance that an effective nitrogen fixing strain of the specific organism is present within the culture.

Referring more particularly to the drawing,

Fig. 1 is a photolithograph picture of a root system of a red clover plant having nodules A located near the crown of the root. Large nodules on the plant near the crown are indicative of good nitrogen fixation and a good strain of the organism.

Fig. 2 shows a control group of forty red clover plants which have grown in a nitrogen-free sand culture for ten weeks with no Rhizobia present. This group had a wet weight of 20.4 grams and total nitrogen content of 27 milligrams derived from the original seeds. No nitrogen was fixed.

Fig. 3 shows the forty-one plants grown under identical conditions as those shown in Fig. 2 but which

were inoculated with a humus inoculant containing only bacteria of the species Rhizobium trifolii alpha prepared in accordance with this invention. The wet weight of this group of plants was 156.7 grams and had a total nitrogen content of 645 milligrams of nitrogen. Thus 618 milligrams of nitrogen were fixed.

Fig. 4 shows a group of forty plants the same as Fig. 3 which were inoculated with a composite inoculant prepared in accordance with one embodiment of this invention containing strains of the species Rhizobium trifolii alpha, Rhizobium meliloti alpha, and Rhizobium japonicum alpha. It will be noted that the red clover plants inoculated with the composite inoculant containing the alpha strains are fully developed to the same extent as the one inoculated with the pure culture and no inhibition is observed in the plant development because of the presence of the other organisms. The wet weight of this group was 159.0 grams and had a total nitrogen content of 662 milligrams. Thus 635 milligrams of nitrogen were fixed.

It will be observed that the organisms of the composite culture described in the foregoing example may be introduced into the culture in any desired numbers and the relative proportion may be fairly accurately predetermined by means of direct bacterial count. The cultures are not mixed until immediately preliminary to their introduction into the carrying material and after they have developed to substantially their maximum numbers. Consequently, there is no danger of one species overgrowing the other during the process of incubation.

The invention is not to be limited in any way to the 1103 number of organisms contained within the inoculant or the number necessary for inoculating a predetermined quantity of seed. In practice, and as shown herein, a large excess of bacteria is generally introduced into the carrying material in order to insure that all of the seeds are thoroughly inoculated with a sufficient number of organisms to produce the desired results.

While several particular embodiments of this invention are shown above, it will be understood, of course,

that the invention is not to be limited thereto since many modifications may be made, and it is contem-
10 plated, therefore [by the appended claims]* to cover any such modifications as fall within the true spirit and scope of this invention as defined by the appended claims.

I claim:

1104 1. A method for producing an inoculant for leguminous plants of the character described which comprises inoculating the surface of a jelly nutrient medium with a culture of bacteria of the genus Rhizobium, incubating the culture on the jelly to permit growth of the bacteria, adding water to the jelly culture, further incubating said culture and incorporating the resulting water suspension of bacteria with an inert, finely comminuted base material.

2. A method for producing an inoculant for leguminous plants of the character described which comprises aseptically spraying the surface of an agar nutrient medium with a culture of bacterium of the genus Rhizobium, incubating the culture on the agar to permit growth of the bacteria, adding water to the agar culture, breaking up the agar mass in the water, further incubating said culture and incorporating the resulting water suspension of bacteria with powdered humus.

3. A method for producing an inoculant for leguminous plants containing inappreciable amounts of nutrient material which comprises growing bacteria of the genus Rhizobium on the surface of a solid nutrient medium, washing said bacteria from the surface with water, incubating further to permit further growth in the wash water in the presence of said solid medium, separating the solid medium from the bacterial suspension, and incorporating the suspension with neutralized humus.

1105 4. In a process for producing an inoculant for leguminous plants of the character described, the improvement which comprises growing bacteria of the genus Rhizobium on the surface of a solid nutrient medium, washing said bacteria from the surface with water, and incubating further to permit further growth in the wash water in the presence of said solid medium.

* Matter in brackets added.

1. 5 An inoculant for leguminous plants comprising a plurality of selected cultures of different species of bacteria of the genus Rhizobium, one of said cultures being Rhizobium trifolii alpha, said cultures being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

2. 6 A bacterial inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium comprising Rhizobium trifolii alpha, Rhizobium meliloti alpha, and Rhizobium japonicum alpha.

3. 7 An inoculant for leguminous plants comprising humus and a mixture of species of bacteria of the genus Rhizobium, said mixture containing a strain of Rhizobium trifolii alpha.

. 8. An inoculant for leguminous plants comprising humus and a mixture of species of bacteria of the genus Rhizobium, said mixture containing a strain of Rhizobium trifolii alpha, said strain of Rhizobium trifolii alpha being characterized by its ability to fix nitrogen in the host plant in the presence of other species of Rhizobia with substantially the same efficiency as when used alone in said inoculant.

1106 9. An inoculant for leguminous plants comprising a plurality of selected strains of different species of bacteria of the genus Rhizobium, comprising Rhizobium trifolii alpha, Rhizobium meliloti alpha, and Rhizobium japonicum alpha in moist powdered humus.

10. An inoculant for leguminous plants comprising a moist powder base, bacteria of the species Rhizobium trifolii, and bacteria of another species of the genus Rhizobium.

11. An inoculant for leguminous plants comprising a moist powder base, bacteria of the species Rhizobium trifolii, and bacteria of another species of the genus Rhizobium, the numbers of bacteria of each species within the inoculant being of substantially the same order of magnitude.

4. 12 An inoculant for leguminous plants comprising a plurality of selected mutually non-inhibitive strains of different species of bacteria of the genus Rhizobium, said strains being unaffected by each

other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

13. An inoculant for leguminous plants comprising a moist powder base and a plurality of selected mutually non-inhibitive strains of different species of bacteria of the genus Rhizobium, said strains being unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

1107 5. 14 An inoculant for leguminous plants comprissing a plurality of strains of different species of bacteria of the genus Rhizobium, at least one of which strains is unaffected by the others in respect to its ability to fix nitrogen in the leguminous plant for which it is specific.

6. 15 An inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium, the bacteria of each strain being present in numbers of substantially the same order of magnitude, said strains being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

10. 16 A method for producing a composite inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium, which comprises cultivating each strain separately in suitable culture medium to produce a substantial quantity of living organisms and thereafter mixing the organisms with a moist powder base containing a substantially negligible concentration of bacterial nutrients whereby the desired inoculant is formed.

17. A method for producing a composite inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium, which comprises cultivating each strain separately on a solid culture medium, washing the bacteria from said medium with water, incubating further in said water in the presence of said medium, and mixing the resulting bacterial suspensions whereby the desired inoculant is formed.

1108 18. A method for producing a composite inoculant for leguminous plants comprising a plurality of

strains of different species of bacteria of the genus Rhizobium, which comprises cultivating each strain separately on a solid culture medium, washing the bacteria from said medium with water, incubating further in said water in the presence of said medium, mixing the resulting bacterial suspensions, and incorporating the mixture into a dry inert powder base.

19. A method for producing a composite inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium, which comprises cultivating each strain separately on a solid culture medium, washing the bacteria from said medium with water, incubating further in said water in the presence of said medium, mixing the resulting bacterial suspensions, and incorporating the mixture into neutralized humus.

20. All novel features in their broadest aspect not otherwise specifically claimed which are disclosed, or are inherent, in the accompanying specification and/or drawings.

1109 In witness whereof, I have hereunto subscribed my name.

Varley Sherman Bond.
(Inventor sign here, including first name in full)

OATH.

State of Illinois }
County of Adams } ss.

Varley Sherman Bond the above named petitioner, being sworn, deposes and says that he is a citizen of the United States and resident of Quincy in the County of Adams and State of Illinois; that he verily believes himself to be the original, first and sole inventor of the improvement in Bacterial Inoculant for Leguminous Plants described and claimed in the annexed specification; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United

States for more than two years prior to this application; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months before this application; and that no application for patent on said improvement has been filed by him or his representatives or assigns in any country foreign to the United States.

VARLEY SHERMAN BOND

(Inventor sign here, including first name in full, and also on line indicated at top of this page)

Subscribed and sworn to before me this 20th day of August, 1938.

RICHARD C. MURRAY
Notary Public.

My commission expires 8/27/41

(Notary must place seal here)
(SEAL)

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Limit of drawing
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Inventor
Varley Sherman Bond
By Ames Thiess Olsen & Mecklenburger
Attys

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1111 DEPARTMENT OF COMMERCE
United States Patent Office
Washington

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE,
Commissioner of Patents,

Ames, Thiess, Olson &
Mecklenburger
77 West Washington St.
Chicago, Illinois

Applicant: Varley S. Bond
Ser. No. 226,565
Filed Aug. 24, 1938
For Bacterial Inoculant
for Leguminous Plants.

Mailed Nov. 9-1938

This application has been examined.
References made of record:

Hendrickson	2,098,918	Nov. 9, 1937	195-54
Bottomley	982,569	Jan. 24, 1911	71-7
Coates	899,155	Sept. 22, 1908	71-7
Stoltz	1,442,239	Jan. 16, 1923	71-7
Earp-Thomas	1,099,121	June 2, 1914	71-6

Coates, Stoltz, and Earp-Thomas teach the suspension of prepared bacteria cultures in humus, phosphate rock, calcium carbonate, soils and prepared fertilizers in general.

Bottomley shows the combination of bacteria culture with bacterial food, and a carrier like humus, etc.

Hendrickson teaches the methods of preparing the cultures of the species of Rhizobium which are effective for the various types of plants.

The applicant has admitted that his alleged invention lies in the use of cultures of a new strain or species of bacteria which do not show the inhibiting effect of one species upon another. Claims 1-4, 10, 11 and 16-19 do not appear to be drawn to the alleged invention and are therefore rejected.

Claims 1-3, 18 and 19 are rejected on Hendrickson in combination with any of Coates, Stoltz or Earp-Thomas.

Claims 4, 10, 11, 16 and 17 are rejected on Hendrickson.

In claims 5-9, drawn to the alleged invention, the new strain of bacteria is referred to as Rhizobium trifolii alpha which name has been applied by the applicant. This is indefinite and confusing as the name has not been used before and the applicant does not known definitely whether a new organism has been isolated. 1112 A better designation of the bacteria culture would be to identify it by its properties.

Claims 5-9 are therefore rejected as indefinite and confusing.

Claims 12-15 appear to be allowable.

P. W. SHEPARD
Examiner

1113

IN THE UNITED STATES PATENT OFFICE

(Stamps) Mail Division, April 29, 1939.

U. S. Patent Office.

U. S. Patent Office May 1, 1939. Division 59.

Application of
Varley Sherman Bond
Serial No. 226,565
Filed August 24, 1938
For Bacterial Inoculant
In Leguminous Plants

} Division 59, Room 4709.

Honorable Commissioner of Patents
Washington, D. C.

Sir:

In response to the Office Action dated November 9, 1938, paper No. 3, please amend the above-identified application as follows:

In the specification, page 18, line 9, cancel "23" and insert therefor 19

line 12, cancel "500" and insert therefor 300

line 13, cancel "750" and insert therefor 450

line 17, cancel "70" and insert therefor 57

Claim 3, line 2, cancel "a small amount" and insert therefor inappreciable amounts

Withdraw claim 20.

Add the following claims:

21. A bacterial inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium including a strain of Rhizobium trifolii, said strain of Rhizobium trifolii being unaffected by the others in respect to its ability to fix nitrogen in the leguminous plant for which it is specific.

1114 22. An inoculant for leguminous plants comprising bacteria selected from a plurality of strains of different species of the genus Rhizobium, at least one of

said strains being identifiable as Rhizobium trifolii which is unaffected by the other strains present in the inoculant in respect to its ability to fix nitrogen in the leguminous plant for which it is specific.

7. 23 A bacterial inoculant for leguminous plants comprising a moist powder base and a plurality of selected mutually non-inhibitive strains of different species of bacteria of the genus Rhizobium including Rhizobium trifolii, the bacteria of each strain being present in numbers of substantially the same order of magnitude, said strains being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

8. 24 A bacterial inoculant for leguminous plants comprising a moist powder base containing a substantially negligible concentration of bacterial nutrients and a plurality of strains of different species of bacteria of the genus Rhizobium, at least one of which strains is unaffected by the others in respect to its ability to fix nitrogen in the leguminous plant for which it is specific.

9. 25 A method for producing a bacterial inoculant for leguminous plants which comprises separately selecting strains of different species of the genus Rhizobium, separately cultivating said strains in nutrient media, and mixing the resulting cultures whereby a composite inoculant is produced, said strains originally being selected so that they are substantially non-inhibitive and non-antagonistic to each other in respect to their ability to fix nitrogen in the host plant for which they are specific.

1115 11. 26 A method for producing a composite bacterial inoculant for leguminous plants which comprises separately cultivating a plurality of strains of bacteria selected from different species of the genus Rhizobium and subsequently mixing the resulting cultures containing large numbers of bacteria whereby a mixture of strains of the bacteria is obtained, the bacteria of each strain being present in numbers of substantially the same order of magnitude.

Respectfully,

VARLEY SHERMAN BOND

By Ames, Thiess, Olson & Mecklenburger

Attorneys.

REMARKS:

The specification has been amended in order to describe a preferred method for incorporating the bacteria with the dry humus in desired numbers in accordance with this invention. The amendment is only directed to specific amounts of bacterial culture that may be added to the humus to produce a commercially desirable inoculant.

Claim 20 has been withdrawn from the case.

The Examiner has indicated in the last Office Action that claims 12 to 15, inclusive, will be allowed.

Claims 5 to 9, inclusive, have been rejected on the basis of the terminology employed in relation to the strains of bacteria contemplated by the applicant in his present invention.

Claims 1 to 4, inclusive, 10, 11, and 16 to 20, inclusive, were rejected on certain references that were cited by the Examiner, and also on the basis that they do not appear to be drawn to the applicant's invention.

1116 *The Invention and the Prior Art*

Before discussing the claims specifically it is believed desirable to make a few remarks about the present invention and its relation to the prior art which has been cited by the Examiner. The applicant has broadly discovered a new method for producing bacterial inoculants for leguminous plants and a composite bacterial inoculant which has not been previously described in the art. The specification discloses a number of closely interrelated and inseparable inventions for which the applicant wishes to obtain patent protection. Claims have been drawn both to a process and product in an attempt to suitably cover all the aspects of the invention. The invention includes a method of cultivating bacteria of the genus Rhizobia in such a manner that the inoculant produced therefrom will contain a large number of organisms in the absence of appreciable amounts of nutrient material derivable from the medium upon which the organism was grown. The applicant has also discovered that a composite inoculant may be produced by combining selected strains of various species of the Rhizobia in a particular manner described in the specification. It is stated in the specification on pages 6 and 7 that these are among the objects of the present inven-

tion, and the Examiner's contention that certain of the claims do not appear to be drawn to the invention as defined by the applicant is clearly in error.

The patent principally relied on by the Examiner in the rejection of the process claims and claims 10 and 11 appears to be patent No. 2,098,918 to Hendrickson. The Hendrickson patent teaches nothing more than the separate growth of Rhizobia on the surface of silica gel medium. This process, however, has nothing whatsoever to do with the process contemplated by the applicant. Claims 1 to 4 and 17 to 19 are all directed to a process for growing bacteria on a solid surface which includes the step of washing the organisms from the surface of the medium and permitting them to incubate further, directly in the wash water that is employed. It has 1117 been found that by this process the number of bacteria that can be obtained from a single jelly slant is very greatly increased. The result is entirely unexpected since a bacteriologist would ordinarily presume that all of the nutrient material had been exhausted while the organism was growing on the surface of the slant and consequently no more development would take place. The applicant has described a means for producing greater numbers of organisms from the same culture medium by the expedient of washing the organisms from the surface and permitting them to develop further directly in the wash water in contact with the solid medium. Hendrickson does not disclose this step nor does any of the art which has been cited by the Examiner. In so much as claims 1 to 4, inclusive, and 17 to 19, inclusive, are drawn to a method which includes this step, it is believed that they are clearly allowable over the art. Claims 10 and 11 were also rejected on the Hendrickson patent. These claims are directed to a composite culture containing the species Rhizobium trifolii. Hendrickson does not even suggest a composite culture and he certainly does not describe one which comprises Rhizobium trifolii admixed with another species of Rhizobium.

Coates in patent No. 899,155 merely describes a composition of matter containing symbiotic nitrogen fixing bacteria admixed with meal and added to fertilizer. Only

a single species of the organism is contemplated and there is no suggestion of either a composite culture or a method such as disclosed by applicant.

The Stolz patent No. 1,442,239 discloses a composition of matter containing the nitrifying bacteria incorporated with a humus, lime and phosphate powder base. The Examiner's attention is directed to the fact that the nitrifying bacteria are not even closely related to the symbiotic nitrogen fixing bacteria which are contemplated by the applicant in the present invention. The nitrifying bacteria function in the soil to transform 1118 inorganic ammonia compounds to nitrites (Nitrosomonas) and nitrites to nitrates (Nitrobacter). The species of Rhizobia contemplated by the applicant, however, act only in symbiotic relationship with the leguminous plants to convert atmospheric nitrogen directly to organic nitrogen within the plant. While Stolz may show the use of humus as a base for a bacterial culture, the applicant does not attempt to claim the use of humus as such per se. He has discovered that the humus is a desirable carrier for the new inoculant prepared in accordance with his invention. Consequently it is not believed that Stolz should be considered anticipatory of any of the claims in the present application, either alone or in combination with any of the other art of record.

Earp-Thomas in patent No. 1,099,121 likewise incorporates bacteria with a soil or humus base. Again, however, it is not believed that this reference is applicable since the novelty of the claims of the present case does not depend entirely on the fact that the organism is mixed with humus or other moist powder base. Applicant's method of cultivating the organisms is not anticipated by this patent.

Patent No. 982,569 to Bottomley describes a process for producing a culture beneficial to soil which comprises a mixture of Pseudomonas radicicola mixed with the culture of Azotobacter. The Pseudomonas described by Bottomley is apparently actually one of the Rhizobia since he states that it is capable of fixing nitrogen while in symbiotic relationship with certain of the leguminous plants. Azotobacter, however, are a well defined bacterial genus which belong to that group of bacteria which fix small quantities of nitrogen in the soil directly, no

symbiosis between it and a higher plant being required. Consequently, Bottomley appears to describe merely a mixture of cultures, one of which belongs to the genus Rhizobia and the other of which belongs to the genus Azotobacter which is a genus entirely unrelated to the Rhizobia. (See Bergey's Manual of Determinative Bacteriology, Williams and Wilkins, 3rd Edition, 1930.) Furthermore, Bottomley contemplates that the culture which he produces is to be inoculated directly into soil upon which non-leguminous plants are to be grown. The effectiveness of this treatment is open to considerable doubt since it is well recognized that the non-leguminous plants such as the grains and cereals are incapable of fixing atmospheric nitrogen either alone or in symbiotic relationship with any bacteria.

1119

Claims Directed to the "Alpha" Strains

The Examiner has rejected claims 5 to 9, inclusive, on the ground of indefiniteness because the applicant has designated the strains of bacteria selected as the alpha strains of the various species of the Rhizobia, such as Rhizobium trifolii alpha, Rhizobia meliloti alpha, and Rhizobium japonicum alpha. It is submitted that the rejection of these claims to the product on this ground is clearly unwarranted. The applicant has gone to great length in the specification to define those particular strains of each species which are used in preparing the composite inoculant described in the present application. It has not been heretofore recognized that certain strains of the Rhizobia are non-inhibitive and non-antagonistic to each other in respect to their ability to fix nitrogen in symbiotic relationship with leguminous plants. The applicant has discovered that, by suitable selection, strains of the various species can be obtained which are mutually non-inhibitive. These particular strains he has chosen to designate by the term "alpha." This practice is clearly not objectionable, since the applicant has the right to employ any terms that he may desire in the claims, so long as they are adequately defined in the specification, whereby one skilled in the art could practice the invention described by the applicant.

The Examiner's attention is directed to the group of patents tha are being continually issued by the 1120 Patent Office from Division 63 relative to fermentation processes carried out by bacteria of the genus Clostridium for the production of butyl alcohol from carbohydrate mashes. With regard to the inventor's right to select and use coined names which depart from the system of names previously used, the Examiner's attention is directed to the following patents:

2,123,078—P-Bacillus
2,096,377—Clostridium saccharo-butyl-isopropyl-acetonicum
2,089,562—Clostridium inverto-acetobutylicum
2,017,572—Clostridium viscifaciens
2,085,428—Clostridium viscifaciens
1,933,682—Bacillus technicus

All of these names have been applied to butyl alcohol fermenting organisms.

The Examiner's attention is further directed to certain recent patents which have issued from the fermentation division which contain claims that are directed to particular strains of a species of an organism similar to the designation employed by the applicant in the present invention. Thus, patent No. 2,063,450 contains claims directed to an alpha strain of Bacillus acetoethylicum. Patent No. 2,016,112 is directed to a gamma strain of Clostridium saccharobutylicum. Patent No. 2,050,219 contains separate claims which are directed to the beta and gamma strains of Clostridium saccharo-acetobutylicum. The organisms described in the claims of these last three mentioned patents are strains of recognized species which were artificially set up by the patentees in the specification in order that they may be more definitely recognized.

The applicant has attempted to use the same approach in the present application in defining the alpha strains of the organisms employed in claims 5 to 9, inclusive. In the specification on pages 16, 17, 19, 20, and 21, a

definite method is pointed out for distinguishing the
1121 alpha strains from other strains of organisms
of the same species. It is, therefore, believed that the term "alpha" as used in the claims is definite and clear in view of the full description in the specification.

Discussion of Individual Claims

In view of the remarks that have been previously made, the Examiner is requested to reconsider his rejection of the originally filed claims and to consider the newly added claims 21 to 26, inclusive.

Claims 1 through 4 are directed to a process for producing an inoculant which comprises inoculating a bacteria of the species Rhizobia on a solid surface, permitting them to develop thereon, adding water to the solid culture, further permitting development of bacteria in the water, and preparing the inoculant from the resulting bacterial suspension. As pointed out, the steps of this process are nowhere suggested in any of the art that has been cited by the Examiner. While it may be true that the development of bacteria on jelly surfaces is old and the incorporation of bacteria into a powder base such as humus is also old, the step of incorporating wash water to the surface of a fully developed jelly culture and further incubating the same, whereby a great increase in numbers of the organisms is obtained, is believed to be new with the applicant. It is believed that he is entitled to patent protection therefor.

Claim 3 has been amended in order to more definitely point out that the neutralized humus with which the culture is incorporated contains only inappreciable amounts of bacterial nutrient material which is desirable for a culture of this type. Appreciable amounts of nutrient do not diffuse from the agar into the wash water while the culture is being incubated in the presence of the water. Consequently, large amounts of nutrient are
not introduced into the humus, as is the case when
1122 cultures that have been entirely developed in liquid
media are introduced therein.

Claims 5 to 9, inclusive, are all directed to a composite inoculant containing a plurality of species of the

Rhizobia, at least one of which is an alpha strain. In view of the full disclosure made in the specification, wherein the alpha strain was defined, and the remarks that have been made above, it is believed that these claims are clearly allowable along with allowed claims 12 to 15, inclusive. The applicant has the right to claim his invention in several different ways if he so desires, so long as the number of claims is not unduly multiplied.

Claims 10 and 11 are directed to an inoculant containing a plurality of species of the Rhizobia including Rhizobium trifolii. A culture of this type is particularly desirable for inoculating the so-called "pasture mixture" of seeds, said mixture usually containing red clover seeds which develop to produce the host plant for which Rhizobium trifolii is specific.

The Examiner has indicated that claims 12 to 15 are allowable.

Claim 16 relates to a method for producing a composite inoculant which comprises separately cultivating a plurality of strains of different species of the bacteria of the genus Rhizobium and subsequently mixing the cultures thus produced in order to produce the desired composite inoculant. The process defined by this claim has not been suggested in any of the art of record. It has been customary in the past, when producing mixed bacterial cultures, to grow the mixture together in one culture. This process is unsatisfactory, howe er, since one species of the organism has a tendency to outgrow the other. Consequently, the resulting culture may contain a relatively large amount of organisms of one species but a comparatively small amount of organisms of another. Such a culture is unsatisfactory for inoculating the seeds of a pluraiity of types of legume cultures which are capable of being infected with the various species
1123 of Rhizobia carried within the inoculant. The process of separately developing the organisms permits them to be introduced separately and in full strength into a powder base material if such is actually employed for the production of the inoculant. The full number introduced into the base may be predetermined.

Claims 17, 18, and 19 are similar to claims 1 through 4, except that they are directed to the preparation of

a composite bacterial culture by separately growing the organisms on a solid culture media, washing the organisms from said media, and permitting them to further develop in the wash water, subsequently mixing the separate cultures so produced to produce the desired inoculant. For the reasons stated above, these claims are also deemed to be clearly allowable.

Claim 20 has been withdrawn from the case.

Newly added claims 21 to 23, inclusive, are directed along the lines of the allowed claims 12 to 15. They are specifically directed to a bacterial inoculant containing Rhizobium trifolii. These claims have been directed specifically to this organism, since it has been considered in the past that it is this organism that was particularly susceptible to the antagonistic action of other species of the Rhizobia when it infects the roots of the host plant for which it is specific. The sensitivity of this organism is particularly pointed out on pages 13 and 14 of the specification. The marked improved results obtained by the strain selected in accordance with the applicant's invention has been pointed out.

Claim 24 is similar to allowed claims 12 to 15, but is more specifically directed to an inoculant which contains substantially negligible quantities of bacterial nutrient in the powdered humus. Such a product is readily obtainable by the method described in process claims 17 to 19. The low nutrient content of the composite culture prevents substantial development of either organism within the material and the numbers of each strain remain in a more or less dormant, although viable, state for long periods of time.

1124

Claim 25 is directed to a method for producing a composite culture which comprises first selecting strains of organisms which are substantially non-inhibitive, separately cultivating them and mixing the cultures to form the desired composite inoculant. The method described in this claim has been clearly described in the specification and is, therefore, believed to be allowable.

Claim 26 is similar to claims 16 and 25, but is directed to a means for producing a bacterial inoculant having large numbers of bacteria of a plurality of strains, the bacteria of each strain being present in numbers of substantially the same order of magnitude.

The applicant has spent considerable time and effort in the preparation of this amendment in an attempt to overcome the Examiner's rejection of claims 1 to 11 and 16 to 19. In view of the remarks that have been made above and in the absence of further prior art, it is believed that they, along with the newly added claims 21 to 26, are clearly allowable. Such action is respectfully requested.

Respectfully submitted,
Ames, Thiess, Olson & Mecklenburger
Attorneys for Applicant

Chicago, Illinois
April 27, 1939

Div. 59 Room 4709 DJH:tis Paper No. 5

1125 DEPARTMENT OF COMMERCE
United States Patent Office
Washington

Please find below a communication from the EXAMINER in charge of this application.

CONWAY P. COE,
Commissioner of Patents,

Ames, Thiess, Olson &
Mecklenburger
77 West Washington Street
Chicago, Ill.

Applicant: Varley Sherman Bond
Ser. No. 226,565
Filed Aug. 24, 1938
For Bacterial Inoculant
for Leguminous Plants
(Stamp) Mailed Sep. 12, 1939

Responsive to amendment filed Apr. 29, 1939.

Additional reference:

Buchanan—"Bacteriology" pp. 120-123, MacMillan Co. (1938) Copy in Div. 63.

The Draftsman has reported that the drawing is informal and not acceptable because the figures are blurred when prints are made. A new drawing with figures on a larger scale will be required.

It appears to be the practice in the division handling the bacteriology arts to permit the claiming of a new

bacteria by a name given by the inventor. The objection to this terminology will not be pressed further but attention of the applicant is called to claims 12-15 and 21-26 which are drawn to same subject matter and are of substantially the same scope as claims 5-9. Applicant will not be permitted to claim the subject matter both by the arbitrarily assigned name and by a description of its properties. Claims 5 and 21 are substantially identical and cancellation of one is required.

The Buchanan reference teaches the elementary principles of bacteria culture. Both liquid and solid culture mediums are widely used each having its peculiar adaptations. In the use of solid mediums the bacteria growth occurs on the surface while in liquid mediums the growth may occur on the surface or under the surface depending on whether or not air is essential to the growth of the particular bacteria. On page 1, column 1126 2, lines 8 et seq. of Hendrickson the procedure is described for removing bacteria from a culture by washing with water to obtain a suspension of the organism in the wash water. Hendrickson uses the water suspension to moisten seeds but in view of Earp-Thomas and Coates there is no invention in using the same water suspension to moisten soil, fertilizers or other carrier agents. It appears obvious that the culture medium may be reused for further incubation. The breaking up of the agar mass to provide additional surface for bacterial growth is a logical procedure which follows from the applicant's desired results which are to produce as many bacteria as possible. No invention is seen in claims 1-4 over Hendrickson and Buchanan in view of any of Stoltz, Earp-Thomas or Coates. Further, there is no relationship between the general cultural methods of claims 1-4 and 16-19 which are obviously adapted to the culture of any bacteria and the new non-inhibitive strain of bacteria which is the subject matter of claims 5-9, 12-15 and 21-25.

Claims 10 and 11 are rejected on the combination of Hendrickson with any of Earp-Thomas, Stoltz and Coates who teach the use of powdered carriers. Hendrickson shows that there are several species of Rhizobium and that each species of legume has a specie of Rhizobium with which it grows best. It appears to be customary to inoculate soils or fertilizers with that specie of bac-

teria suited to crop to be grown. When a plurality of crops are to be grown it is obvious to mix a plurality of bacteria species.

The applicant has acknowledged as part of the prior art (page 5 of specification) that the presence of more than one species of bacteria in a culture will cause the inhibition of all. It is submitted that where a product is required containing a plurality of species of which 1127 may not be cultivated together because of the inhibitory effect, it is elementary to grow them separately and combine them in the final mixture. A very clear teaching of this is found in Earp-Thomas (page 2, line 55 et seq.) He states that soils may be inoculated with a single or a variety of species of bacteria which may be grown in a single or separate cultures. Obviously if the species are known to be mutually inhibitory separate cultures will be used. Thus claims 10, 11, 16 and 26, are unpatentable over either Hendrickson or Earp-Thomas.

Claims 17, 18 and 19 are rejected as unpatentable over either Hendrickson or Earp-Thomas who show the use of plurality of bacterial strains with the conventional culture procedure as taught by Hendrickson and Buchanan and with the inert carrier as used by Coates, Earp-Thomas and Stoltz.

Claims 5-9, 12-15 and 21-25 are allowable.

Attention of applicant is called to the minute distinctions which exist between certain of the claims indicated as allowable. Examiner believes that the invention is of such nature that it can be covered completely by half of number of claims now in the case. Applicant will, therefore, be required to limit his claims under the doctrine of Ex parte Schwartz 1935 C. D. 23 and to differentiate clearly each from the other.

Claims 1-4, 10, 11, 16-19 and 22 and 26 are rejected.

P. W. SHEPARD
Examiner.

1128 IN THE UNITED STATES PATENT OFFICE

U. S. Patent Office
Feb. 9, 1940
Division 59

Div. 59 Room 4709
Application of
Varley Sherman Bond
Filed Aug. 24, 1938
Serial No. 226,565

Hon. Commissioner of Patents:
Washington, D. C.

Sir:

The undersigned, attorneys of record in the above-entitled case, hereby appoint Thiess, Olson & Mecklenburger, a firm composed of J. Bernhard Thiess, Arthur A. Olson, A. F. Mecklenburger, Willard L. Pollard, George W. Hansen, A. Arnold Brand, Thorley von Holst, Bertram Wm. Coltman, Albert H. Pendleton, Carl Marx, Arthur B. Seibold, Jr., and Sidney Neuman, of 77 West Washington Street, Chicago, County of Cook, and State of Illinois, substitute attorneys in their place and stead, with power of substitution and revocation, to prosecute the above application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent Office connected therewith.

Chicago, County of Cook, State of Illinois, this 1st day of February, 1940.

Ames, Thiess, Olson & Mecklenburger
Attorneys.

1129 IN THE UNITED STATES PATENT OFFICE

U. S. Patent Office
Mar. 12, 1940
Division 59

Application of
Varley Sherman Bond
Serial No. 226,565
Filed August 24, 1938
For Bacterial Inoculant
for Leguminous Plants

Division 59, Room 4709.

HON. COMMISSIONER OF PATENTS
Washington, D. C.

Sir:

In response to the Office Action dated September 12, 1939, Paper No. 5, please amend the above-identified application as follows:

In the specification, page 8, line 23, cancel "is" (first occurrence) and insert therefor are

Page 23, line 10, before "to" insert by the appended claims

line 12, cancel "as defined by the appended claims"

In the claims, withdraw claims 1, 2, 3, 4, 8, 9, 10, 11, 13, 17, 18, 19, 21, and 22.

Claim 16, line 6, after "organisms" insert with a moist powder base containing a substantially negligible concentration of bacterial nutrients

Claim 26, line 6, cancel "whereby a mixture of strains of the bacteria" and substitute therefor with a moist powder base containing a substantially negligible concentration of bacterial nutrients whereby the desired inoculant

1130 Add the following claims:

12. 27 A method for producing a composite inoculant for leguminous plants which comprises separately cultivating a plurality of species of bacteria of the genus Rhizobium in separate cultures and mixing with a powder base predetermined numbers of the bacteria of each cul-

ture to produce the desired inoculant, said powder base being substantially free of added bacterial nutrients.

13. 28 A bacterial inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium in numbers of substantially the same order of magnitude incorporated with a powder base, the mixture being substantially free of bacterial nutrients whereby growth of the bacteria therein is inhibited.

14. 29 The inoculant as defined in claim 28 [13]* wherein one of said species is Rhizobium trifolii.

Respectfully,
VARLEY SHERMAN BOND
By Thiess, Olson & Mecklenburger
Attorneys.

REMARKS:

Minor changes have been made in the specification. Claims 1 through 4, 8 through 11, 13, 17 through 19, 21, and 22 have been withdrawn from the case. Claims 16 and 26 have been amended. Claims 27, 28, and 29 have been added. In view of the amendments that have been made, the Examiner is respectfully requested to consider the claims as they now stand in the case.

The Examiner has indicated in the last Office Action that a new drawing with figures on a larger scale is required. Accordingly, a new sheet of drawings is enclosed herewith which shows enlarged reproductions of the same plants and root system that were shown in the drawings originally filed in the case. It is believed that these drawings are in such condition as to overcome the objection made by the Official Draftsman. If, however, the new drawings are unsatisfactory, the applicant will furnish the prints from which they were made so that the Official Draftsman may make drawings to his own satisfaction in accordance with Rule 55 of the Rules of Practice.

The Examiner has objected that there is no relationship between the cultural method such as recited in claim 16 and the new noninhibitive strain of bacteria which is claimed in the allowed claims in the case. It is submitted that the Examiner is laboring under a misapprehension as to the true nature of the applicant's present invention. While it is true that the applicant has disclosed and claimed a new type of noninhibitive strain of the several

* Matter in brackets added

Rhizobia which may be employed in the preparation of a composite culture, he has also disclosed a new and satisfactory method for producing composite cultures in general which have not been disclosed or even remotely suggested in any of the references of record, and it is believed that he is entitled to claims directed to this new process. It is clearly pointed out in the specification as filed that certain objects of the invention are to provide a method or methods for introducing a bacterial culture into a suitable carrying material whereby a bacterial inoculant is produced which will retain its viability and effectiveness over long periods of time. Thus, a process has been described for incorporating a plurality of strains of organisms into a single culture in such a manner that each of the strains so incorporated will be present in predetermined numbers and will maintain its viability throughout the normal commercially useful period of 1132 the culture. One means for obtaining this result has been to incorporate into the composite culture strains of mutually noninhibitive bacteria. This is but one of the important factors. In a composite culture such as proposed by the applicant it is important that each species be grown separately before mixing, that each species be present in the mixed culture in a definite predetermined proportion, and that the base be substantially free from bacterial nutrients. This is necessary so that the culture may be effective in inoculating the seeds of any of the plants of the several cross inoculation groups for which the inoculant was originally prepared.

Earp-Thomas has indicated that a mixed culture may be prepared by inoculating several organisms into a soil base with which have been incorporated substantial quantities of carbohydrates or other bacterial nutrients (see page 2, lines 5-8). Earp-Thomas contemplates that only relatively small numbers of each species be inoculated into the nutrient-containing moist base and he then relies on subsequent growth of each culture therein to produce the desired composite inoculant. This process is not satisfactory because the more rapidly growing strains outgrow those strains which develop more slowly. Thus, when the composite culture is prepared in accordance with the disclosure in Earp-Thomas, certain strains, such as a culture

of Rhibozium trifolii, will develop rapidly in the nutrient-containing moist base, due to their rapid growth characteristics, while a slower growing strain, such as Rhizobium japonicum, is suppressed. The resulting composite culture is, therefore, composed principally of the more rapidly developing strains, and only relatively small numbers of the more slowly developing strains are present, and consequently the resulting culture is inefficient 1133 for inoculating the seeds of plants which are infected by the normally slower growing organism. Furthermore, soil cultures prepared in accordance with the method suggested by Earp-Thomas have a high concentration of metabolic products of the bacteria developing therein, which products have a tendency to adversely affect the viability of the culture. Thus, the normal commercial shelf life of the Earp-Thomas product is much shorter than that proposed by the applicant.

The applicant has discovered that a composite culture containing a plurality of species of bacteria in predetermined numbers may be prepared by separately cultivating the organisms to obtain a desired number of bacteria of each species and thereafter mixing them with a moist powder base which is substantially free of bacterial nutrients in order to prevent subsequent overgrowth of the more rapidly developing species within the commercial inoculant thus produced. The applicant has been able by this process to produce a mixed culture in which the organisms of the several species may be present in predetermined relative concentrations. This method, which is recited by claims 16 and 26 as amended, is clearly not disclosed in any of the references cited by the Examiner. The Earp-Thomas patent is not pertinent, since it discloses a method in which the organisms are inoculated into a moist soil base having substantial quantities of a bacterial nutrient, thus readily permitting a rapidly developing species to outgrow a more slowly developing species when the culture is stored.

The Examiner has stated:

> "... It is submitted that where a product is required containing a plurality of species of which may not be cultivated together because of the inhibitory effect, it is elementary to grow them separately and combine them in the final mixture."

1134 The Examiner is apparently laboring under a misapprehension as to the meaning of "inhibitory" as employed by the applicant throughout the specification and claims. The term does not necessarily refer to mutual inhibition of bacteria as regards their growth in a common culture medium, although it may under certain conditions. It refers principally to the inhibitive effect of the organisms exerted on each other in respect to the power to produce proper nodulation on or fix nitrogen in the leguminous plant for which each is specific. Thus, one species growing in a mixed culture medium may have a tendency to outgrow another, but either or both may have an inhibitory effect on the other in a composite culture in regard to its ability to infect the host plant and to fix nitrogen therein. For example, if Rhizobium trifolii and Rhizobium japonicum are inoculated into a single culture medium, the trifolii, having a more rapid growth rate will usually outgrow the japonicum. However, if the seeds of a clover plant are inoculated with a mixed culture containing trifolii (not an alpha strain) and japonicum, the japonicum species will inhibit the trifolii in the latter's ability to infect the roots of the clover plant and to fix nitrogen therein. Consequently, there is no correlation between the "inhibitory" powers of the various species of the Rhizobia (as used in the present specification) and the rate of growth of each species in a common culture medium. The applicant has discovered that separate growth of the cultures and their mixing provides a method in which the approximate numbers of each species may be controlled and results in a product which will remain viable and effective over a long period of time. This process has not been suggested by any of the art of record and it is believed that the applicant is entitled to patent protection therefor.

1135 The Examiner has indicated in the last Office Action that claims 5 though 9, 12 through 15, and 21 through 25 were allowable. He has indicated, however, that the number of allowed claims should be reduced. Consequently, allowed claims 8, 9, 13, 21, and 22 have been withdrawn from the case, since it is believed that the remaining allowed claims are sufficient to define that feature of the applicant's invention directed to the noninhibitive

strains of the micro-organisms. They are all clearly patentably distinguishable from each other.

Claim 5 is directed to an inoculant comprising a plurality of selected cultures including Rhizobium trifolii alpha, which cultures are substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

Claim 6 is directed to a bacterial inoculant comprising Rhizobium trifolii alpha, Rhizobium meliloti alpha, and Rhizobium japonicum alpha.

Claim 7 is similar to claim 5, but specifically recites an inoculant comprising humus and Rhizobium trifolii alpha.

Claim 12 is directed broadly to an inoculant comprising a plurality of selected mutually noninhibitive strains of the Rhizobia. This claim thus includes other species of Rhizobia than those specified in claim 6.

Claim 14 is somewhat broader than claim 12 and recites that at least one of the strains present is not inhibited by the others in respect to its ability to fix nitrogen in the leguminous plant for which it is specific.

Claim 15 is similar to claim 12, but further points out that the bacteria of each strain are present in numbers of substantially the same order of magnitude.

1136 Claim 23 is similar to claim 5, but further recites that the inoculant has a moist powder base and that the numbers of the bacteria of each strain are of the same order of magnitude.

Claim 24 distinguishes from claim 14 in that it recites a moist powder base containing a substantially negligible concentration of bacterial nutrients.

Claim 25 recites a method of producing the inoculant set forth in the previously discussed claims which comprises first selecting the noninhibiting strains and subsequently cultivating them separately and mixing the resulting cultures to produce the composite inoculant.

From the above considerations, it is clear that all of the allowed claims are clearly patentably distinguishable from each other.

Amended claims 16 and 26 and newly added claim 27 are directed to the above-discussed method of preparing composite cultures which comprises separately cultivating the organisms and thereafter mixing them with a

moist powder base containing a substantially negligible concentration of bacterial nutrients. Newly added claims 28 and 29 are directed to a product resulting from the process which is clearly distinguishable from the art of record.

Claim 16 is the broad claim of this group, reciting a method in which each strain of several species of Rhizobium is separately cultivated before mixing with a moist powder base containing a substantially negligible concentration of bacterial nutrients.

Claim 26 is similar to claim 16, but further recites that the bacteria of each strain so mixed are present in the resulting inoculant in numbers of substantially the same order of magnitude.

1137 Claim 27 is similar to claim 16, but recites that the bacteria of each species is cultivated separately in suitable culture medium and thereafter mixed with the moist powder base in predetermined ratios, said powder being substantially free of added bacterial nutrients.

Claim 28 is directed to a composite culture prepared in accordance with the method recited in claim 26. The product suggested in Earp-Thomas clearly does not have the characteristics recited by this claim.

Claim 29 is dependent upon claim 28 and specifically recites that one of said species is Rhizobium trifolii.

It is submitted that neither of the patents to Hendrickson or Earp-Thomas anticipates any of the claims 16, 26, 27, 28, or 29. As pointed out above, Earp-Thomas contemplated that the bacteria be introduced into a soil base which contained considerable quantities of a carbohydrate or other bacterial nutrient to permit subsequent development of the organisms thereon. This is clearly an undesirable feature of his process and product; the applicant has distinguished from it, and it is believed that he is entitled to patent protection for his disclosure.

The patent to Hendrickson has been carefully considered and the Examiner is respectfully requested to point out wherein there is any disclosure of a method for producing a composite culture. The disclosure in this patent merely relates to a method of cultivating bacteria on a silica gel. The applicant is unable to find a disclosure of a method for producing a composite culture.

Discussion of the remaining references considered by

the Examiner in the last Office Action is believed to be unnecessary because of the withdrawal by the present amendment of certain claims in the application against 1138 which these references were applied. All of the claims as they now stand in the case are believed to be clearly in condition for allowance and such action is respectfully requested.

Respectfully submitted,
Thiess, Olson & Mecklenburger
Attorneys for Applicant.

Chicago, Illinois,
March 9, 1940.

1139

Div. 59 Room 4709 Serial No. 226,565

DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE

Washington

(Stamp) Mailed Apr. 1 1940

Varley Sherman Bond, Assor. April one, 1940

Your APPLICATION for a patent for an IMPROVEMENT in Bacterial Inoculant for Leguminous Plants filed 8-24-38 has been examined and ALLOWED with 14 claims.

The final fee, THIRTY DOLLARS, WITH $1 ADDITIONAL FOR EACH CLAIM ALLOWED IN EXCESS OF 20, must be paid not later than SIX MONTHS from the date of this present notice of allowance. If the final fee be not paid within that period, the patent will be withheld; SEE REVISED STATUTES, SECTION 4885 AS AMENDED BY ACT OF CONGRESS APPROVED AUGUST 9, 1939.

The office delivers patents upon the day of their date, on which date their term begins to run. The preparation of the patent for final signing and sealing will require about four weeks, and such work will not be begun until after payment of the necessary final fee.

When the final fee is paid, there should also be sent, DISTINCTLY AND PLAINLY WRITTEN, the name of the INVENTOR, TITLE OF THE INVENTION, AND SERIAL NUMBER AS ABOVE GIVEN, DATE OF ALLOWANCE (which is the date of this circular), DATE OF FILING, and, if assigned, the NAMES OF THE ASSIGNEES.

If it is desired to have the patent issue to an ASSIGNEE OR ASSIGNEES, an assignment containing a REQUEST to that effect, together with the FEE for recording the same, must be filed in this office on or before the date of payment of the final fee.

After issue of the patent, uncertified copies of the drawings and specifications may be purchased at the price of TEN CENTS EACH. The money should accompany the order. Postage stamps will not be received.

The final fee will NOT be received from other

IN REMITTING THE FINAL FEE GIVE THE SERIAL NUMBER AT THE HEAD OF THIS NOTICE.

UNCERTIFIED CHECKS WILL NOT BE ACCEPTED.

than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

NOTICE.—WHEN THE NUMBER OF CLAIMS ALLOWED IS IN EXCESS OF 20, NO SUM LESS THAN $30 PLUS $1 ADDITIONAL FOR EACH CLAIM IN EXCESS OF TWENTY CAN BE ACCEPTED AS THE FINAL FEE.

Respectfully,
Conway P. Coe
Commissioner of Patents.

THIS APPLICATION
CANNOT BE RENEWED.
Thiess, Olson & Mecklenburger,
77 W. Washington St.
Chicago, Illinois.

1140 IN THE UNITED STATES PATENT OFFICE

Apr-13-40 200295 B-Check—30.00

(Stamp) Mail Division
Apr. 13, 1940
U. S. Patent Office

Application of
Varley Sherman Bond
Serial No. 226,565
Filed August 24, 1938
For Bacterial Inoculant
for Leguminous Plants
Assigned to Kalo Inoculant Company
Allowed April 1, 1940

Division 59
Room 4709

Honorable Commissioner of Patents
Washington, D. C.

Sir:

We enclose our check for $30.00 in payment of the final fee in the above-identified application. Please have the patent issue in the name of the Kalo Inoculant Company.

Respectfully,
Thiess, Olson & Mecklenburger

Chicago, Illinois
April 11, 1940

1149

DISTRICT COURT OF THE UNITED STATES
Southern District of Illinois

HONORABLE COMMISSIONER OF PATENTS,
Washington, D. C.

Sir:

In compliance with the Act of February 18, 1922 (42 Stat. L. 392), you are advised that there was filed on the 10th day of December, 1943, in this court an action, suit, or proceeding No. Civil Q-62, entitled:
Name Kala Inoculant Company, a corporation, Plaintiff,
Address Quincy, Illinois.

versus

Name Funk Brothers Seed Company, a corporation, Defendant,
Address Bloomington, Illinois.
brought upon the following patents:

	Patent No.	Date of Patent	Patentee
1	2,200,532	May 14, 1940	Varley Sherman Bond
2	.....	.....	.....
3	.....	.....	.....
4	.....	.....	.....
5	.....	.....	.....

In the above-entitled case, on the ..... day of ....., 193 , the following patents have been included by ..... (insert amendment, answer, cross bill, or other pleading):

	Patent No.	Date of Patent	Patentee
1	.....	.....	.....
2	.....	.....	.....
3	.....	.....	.....
4	.....	.....	.....
5	.....	.....	.....

In the above-entitled case the following decision has been rendered or decree issued:

.....

.....

IN WITNESS WHEREOF I have affixed my hand this 10th day of December, 1943, at Quincy, Illinois.

G. W. Schwaner
(sgd) G. W. Schwaner
Clerk of said Court.

1150 In The

DISTRICT COURT OF THE UNITED STATES
For The Southern District Of Illinois
Southern Division

Quincy, Illinois
December 10, 1943

The Attorney General,
Washington, D. C.,

Sir:

In compliance with your request of June 2, 1942, you are advised that there was filed on the 10th day of December, 1943, in this court, an action bearing general No. 62, Civil Action, entitled as follows:

Name Kalo Inoculant Company, a corporation, Plaintiff
Address Quincy, Illinois.

-vs-

Name Funk Brothers Seed Company, A corporation, Defendant.
Address Bloomington, Illinois.
brought upon the following patents:

Patent No.	Date of Patent	Patentee
2,200,532	May 14, 1940	Varley Sherman Bond

.....

.....

TRIAL CALENDAR STATUS

Summons issued December 10, 1943, returnable in twenty days.

.....

.....

In witness whereof, I have affixed my hand this 10th day of December, A. D. 1943, at Quincy, Illinois.

G. W. Schwaner
Clerk, U. S. District Court
Southern District of Illinois.

clf

1151 — 1938

CONTENTS

1. Application.....papers
2. Print 8-29-38
3. Rejection Nov. 9-1938
4. Amdt. A Apr. 29, 1939
5. Rejection Sep. 12, 1939
6. Sub Pow. Feb. 8, 1940
7. Amdt. B & Sheet Drg. Mar. 11, 1940
8. Notice of Suit Jan. 14-1944
9. Notice of Suit Mar. 6-1944
10. .....
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14. ..... 63 226565
15. .....
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18. .....
19. .....
20. .....

U. S. Patent Office
Oct. 18, 1938
Division 59

DEFENDANT'S EXHIBIT 35.

1152 last analysis, the effect will be explainable in terms of physics and chemistry. But for the present we cover our ignorance by speaking of symbiosis and antagonism, according as the net effect of the association of organisms is beneficial or harmful to the rhizobia. The nodule bacteria have undoubtedly existed in the soil and tissues of the Leguminosae for ages. Why are they not more abundant and more widely distributed? Perhaps the answer is that the antagonism of other soil microörganisms holds them in check. As early as 1899b Nobbe and Hiltner suggested that the competition between rhizobia and the rest of the soil flora results in harm to the rhizobia; they implicated both bacteria and fungi in the opposition. Sackett, 1906, in a laboratory study of associated growth of *B. ramosus* and *Ps. radicicola,* observed that multiplication of the latter is greatly inhibited. Simon, 1907, apparently the first to study the rhizobia in natural soil, reported that the soil flora is definitely antagonistic to the nodule organisms, and in a later paper, 1911, asserted that the presence of fungi is particularly harmful. From the fact that rhizobia grow better in sterilized soil than in natural unsterilized soil, Duggar and Prucha, 1912, argued that there is an antagonistic action of the general soil flora toward the rhizobia. Kühn, 1911, on finding poor results with certain commercial cultures on seeds in rich humus soil, reasoned that competing microörganisms in such a soil destroy the rhizobia. Other investigators, however, are only willing to grant that certain bacteria of the soil flora are harmful. Kellerman and Robinson, 1906, reported an organism resembling *B. coli* to be inhibitory to the rhizobia. A year later Kellerman and Fawcett, 1907, found that *B. ochraceus* in a liquid medium has no effect upon nodule bacteria, whereas an organism like *B. coli* is distinctly harmful. In soil, however, no harmful effect is noted. Kalantarov, 1914, showed that *Bacillus mycoides* and *Bacterium fluorescens liquefaciens* neither in soil nor in culture media influence the nodule bacteria. On the other hand, he observed that *Bacillus mesentericus*

vulgatus and *Bacterium coli communis* are strongly antagonistic. Alicante, 1926, found a number of organisms non-injurious to the rhizobia; namely *B. radiobacter, Azotobacter chroococcum, B. prodigiosus, B. capsulatus, B. subtilis, B. mesentericus,* a pink yeast, and some molds. *A mixture of nodule bacteria from pea, clover, cowpea, and soybean nodules are likewise not mutually antagonistic.*

While at Wisconsin, *Konishi,* 1931, obtained some interesting data on the relation of certain soil bacteria to the rhizobia. He isolated several unidentified organisms from soil and tested them out with rhizobia in liquid medium, with and without $CaCO_3$, and also in soil. He found inherent differences in the degree of antagonism exhibited by the cultures and also differences according to the conditions of the experiment. In general, the effects were most severe in liquid media without $CaCO_3$ and least severe in soil. Certain known cultures of soil bacteria were tested and also found most injurious in liquid. For example, *B. subtilis* inhibits *Rh. meliloti, Rh. leguminosarum,* and *Rh. japonicum* in liquid cultures, but not in soil. *B. coli* likewise is without effect on *Rh. meliloti* in soil. The other organisms tested, *B. mycoides, B. megatherium, B. prodigiosus, B. fluorescens,* and *B. aerogenes,* are also harmless in soil.

So much for the antagonistic or neutral side to the competition. There remain to be considered a few reports on the beneficial effects of certain organisms upon the rhizobia. Hiltner, 1907, stated that the presence of another organism

DEFENDANT'S EX. 36.

1153 exhibits slower and less profuse growth and an alkaline reaction, rarely, if ever, an acid reaction. Associated with these characters is a difference in the growth of the organisms in milk. The first group produces a serum zone without coagulation, while the second group gives no macroscopic change in the milk. To the first group belong the organisms from alfalfa, clover, pea, bean, and Dalea, and to the second, the organisms of soybean, cowpea, and lupine.

As the study of these organisms has continued, it has become increasingly apparent that these two large groups can be further subdivided on the basis of cultural and physiological characters. These groupings follow the lines of the cross-inoculation groups; and although the differences are not as distinct as those separating the two main groups, it is evident that the organisms of the various cross-inoculation groups are not identical, either culturally or physiologically. The work of Müller and Stapp, 1925, is the most thorough and exhaustive yet published, but the reports of Simon, 1911, and of Prucha, 1915, with the organism from pea; of Wilson, 1917, and Wright, 1925a, with the organism from soybean; of Stevens, 1925a, with the organism from alfalfa; of Gangulee, 1926a and b, with the organism from *Crotalaria juncea;* of Whiting, Fred, and Helz, 1926, with the organism from Dalea; and of Eckhardt, Baldwin, and Fred, 1931, with the organism from *Lupinus* deserve mention.

Studies on the fermentative characters and gelatin liquefaction by the various rhizobia have been carried out by a number of workers recently. It has been found that significant differences do exist; these have been stated fully in Chapter 6 and will be introduced wherever useful in the species characterization which will be given later in this chapter. In some cases the variation between the reaction of known strains of the same rhizobium is so great that apparent differences between cross-inoculation groups cannot be urged too far. One would hesitate to identify an unknown culture of rhizobia entirely on the basis of fer-

mentative characters; yet the authors feel that the fermentation reactions are valuable aids in species characterization and should be used as far as may be.

Serological reactions. With the development of serological reactions by workers with animal pathogens and their general adoption as an aid in species identification, a number of studies were made on the antigenic specificity of the rhizobia. The early results of Zipfel, 1911; Krüger, 1914; Klimmer and Krüger, 1914; Simon, 1914; Vogel and Zipfel, 1921; Klimmer, 1922; and Aso and Ohkawara, 1926; as well as the more recent studies of Walker, 1928, indicated that certain serological reactions, particularly the agglutination test, might be used to separate the various species of rhizobia. In each instance one, or at most a very few, strains of each species were tested. The results with such a limited number of strains render of little value the sweeping conclusions which were often drawn. The fact that in no instance was cross agglutination observed between different species is probably satisfactory evidence for the conclusion that the species are serologically distinct. On the other hand, the assumption by several investigators that all strains of a species are serologically identical has little basis in fact.

Several serological groups have been recognized within the species by a number of workers: Bialosuknia, 1923; Bialosuknia and Klott, 1923; Stevens, 1923 and 1925a; Wright, 1925a; Ohkawara and Yoshida, 1925 (see Jimbo, 1930); Israilsky, 1929; and Jimbo, 1930. The work of Stevens, 1923, is the most exten-

1154 And afterwards, to-wit: on the 27th day of September, A. D. 1945, the following further proceedings were had in said Court in said cause and were entered of record, to-wit:

1155 IN THE DISTRICT COURT OF THE UNITED STATES
Southern District of Illinois
Southern Division

Kalo Inoculant Company, Plaintiff, *vs.* Funk Brothers Seed Company, Defendant.	Civil Action No. Q-62

MEMORANDUM OF HOLDINGS

With some reluctance I find that the claims in suit of the Bond patent are invalid under our patent statute because they do not involve the invention or discovery of "any new and useful art, machine, manufacture, or composition of matter." I say, "with reluctance," because I was impressed at the trial with the very great diligence and ingenuity of Mr. Bond and with the results he obtained. His work is not to be minimized. Notwithstanding the value of his work, however, I feel quite positive that it cannot be classified under any of the subjects covered by the Act and must, therefore, be held nonpatentable. I deem this holding to be in harmony with the weight of authority and not in conflict with the decision in Dennis v. Pitner. This is sufficient to dispose of the case, but if it is desired by counsel that I pass upon other questions at issue my holding will be, as follows:—

1. If valid Legume-Aid infringes.
2. Finding in favor of Plaintiff on issue of "unclean hands."
3. Bond is the sole inventor.

Plaintiff has limited its charges of infringement in this proceeding to those arising under claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 and these I have held invalid. The other claims I deem not to be at issue, and the defendant in this proceeding is not entitled to any relief by way of declaratory

judgment concerning them. The counterclaim will, therefore, be dismissed.

This memorandum of holdings is intended as a guide in the preparation of findings. Counsel for defendant may prepare and submit (first to opposing counsel) findings of fact, conclusions of law and decree.

(signed) Chas. G. Briggle
U. S. District Judge

Endorsed, Filed September 27, 1945 G. W. Schwaner, Clerk.

1156 And afterwards, to-wit: on the 10th day of October, A. D. 1945, the following further proceedings were had in said Court in said cause and were entered of record, to-wit:

1157 IN THE DISTRICT COURT OF THE UNITED STATES
For the Southern District of Illinois
Southern Division

Kalo Inoculant Company, Plaintiff,
vs.
Funk Brothers Seed Co., Defendant.
} Civil Action No. Q-62

FINDINGS OF FACT AND CONCLUSIONS OF LAW

This cause having come on to be heard regularly by the Court sitting without a jury and the same having been submitted upon the pleadings, all of the proceedings had herein and the evidence introduced at the trial, oral argument having been had in open Court and briefs filed by counsel for all the parties; and the Court having taken the same under advisement and indicated to counsel in a Memorandum of Holdings its decision as to the issues involved, the Court does hereby make and file its Findings of Fact and Conclusions of Law pursuant to the provisions of Rule 52 of the Federal Rules of Civil Procedure.

1.

This is a patent infringement suit brought by the Kalo Inoculant Company, an Illinois corporation, against Funk Brothers Seed Company, also an Illinois corporation, based upon U. S. Letters Patent No. 2,200,532 granted May 14, 1940, to Varley Sherman Bond, Quincy, Illinois, assignor to Kalo Inoculant Company, Quincy, Illinois, entitled "Bacterial Inoculant for Leguminous Plants."

2.

The patent in suit contains some fourteen claims in all, Claims 9, 10, 11 and 12 being process or method claims. All of the other claims are product or article claims. By stipulation of counsel the Plaintiff limited its charge of infringement to those arising under product Claims 1, 3, 4, 5, 6, 7, 8, 13 and 14.

3.

By amendment the Defendant further averred that 1158 the patentee had made false statements to the Patent Office pending the application for the patent here involved and that as a consequence the Plaintiff in this action does not come into Court with clean hands and should, therefore, be held to be without any remedy. The answer further embraced a counterclaim under the declaratory judgment Act of 1934, Section 274(d) of the Judicial Code of the United States, 28 U.S.C.A. 400 and prayed for a judgment declaring the Bond patent in suit No. 2,200,532 wholly null and void and invalid in law as to all claims thereof, and, if valid, not infringed by the Defendant. To this counterclaim the Plaintiff in due season filed its reply traversing the issues raised under the same.

4.

The specific acts of infringement complained of took place in the City of Bloomington, Illinois, in the Southern Division of the Southern District of Illinois, within the jurisdiction of this Court, and subsequent to the issue of the patent in suit and consisted of the sale by the Defendant of record, Funk Brothers Seed Company, of a bac-

terial inoculant for leguminous plants under the trade mark or name of "Legume-Aid."

5.

The bacterial inoculant sold under the trade mark or trade name "Legume-Aid," is a product manufactured and sold by The Agricultural Laboratories, Inc. of Columbus, Ohio, a corporation of the State of Ohio, which company, openly and avowedly, assumed the defense of this action and controlled the same though said company was not made a formal party Defendant of record. The accused product here involved was manufactured by The Agricultural Laboratories, Inc. and sold by it to the defendant of record, Funk Brothers Seed Company, which Defendant in turn sold the same to its customers within the jurisdiction of this Court, and within the period of six years next preceding the filing of the Bill of Complaint herein and subsequent to the date of issue of said Bond patent in suit No. 2,200,532.

6.

Jurisdiction of the Court is based upon the Patent
1159 Laws of the United States and no issue was raised by either party as to the same.

7.

The Plaintiff is the owner of the Bond patent in suit No. 2,200,532 and has been the owner of the same at all times since the issuance of the patent on May 14, 1940.

8.

The Bond patent in suit is entitled "Bacterial Inoculant for Leguminous Plants" and in general relates to a bacterial culture for use in the inoculation of leguminous plants. It discloses and claims a composite culture in which there is mixed a plurality of different species of bacteria belonging to the general genus known as Rhizobium in a common powder base. The claimed inventive thought of the Bond patent rests primarily upon the fact that the separate cultures of these different species in the composite inoculant are unaffected by the others in respect

to their ability to fix nitrogen in the leguminous plant for which each is specific.

9.

There are certain species of the Rhizobium bacteria that are specific to one group of leguminous plants and other species of the same genus Rhizobium that are specific to another group of leguminous plants. These groups of leguminous plants that may be infected by a single species or strain of the genus Rhizobium bacteria are known as cross inoculation groups.

10.

These bacteria of the genus Rhizobia which are capable of infecting leguminous plants so that nitrogen may be fixed are widely spread in nature. The mechanism of this nitrogen fixation is concededly not understood at the present time, but it has been known for a number of years that it can only be carried out when the plant grows in symbiotic relationship with certain bacteria of the genus Rhizobia. Plants belonging to the genus Leguminosae which are capable of symbiotic relationship with the Rhizobia are peas, beans, alfalfa, red clover, white clover, vetch, 1160 lupines and the like. The bacteria infect the roots of these plants in the soil and cause the formation of so-called nodules, in which it is presumed that the nitrogen fixation in the plant occurs.

11.

It was well known in the art long before the claimed invention or discovery of Bond that the genus Rhizobium bacteria possessed this nitrogen fixation characteristic when a certain species or strain of the same was applied in symbiotic relationship to the leguminous plant of the cross inoculation group to which the particular species or strain was specific. Also long before the advent of Bond in this field, manufacturers of inoculants had taken these bacteria as found widely scattered in nature where they performed this nodulation or nitrogen fixation and by a laboratory method of culture increased the number of the bacteria without in any way changing their form, shape or characteristics physiologically or otherwise and then placed

them in a powder or liquid base or carrying medium and packaged the same for sale to and use by agriculturists, farmers and others in the inoculation of leguminous plants.

12.

The patentee Bond did not invent any new strain or species of the Rhizobium bacteria but he discovered the fact that among the bacteria found widely spread in nature there existed both mutually inhibitive and mutually non-inhibitive strains which can be selected and isolated and when so selected and isolated perform the same function that they do in nature. The method of culture of single strains of these bacteria set forth in the Bond patent in suit was well known in the art long before Bond's claimed invention or discovery. His method of placing the bacteria in the carrying medium or base was a conventional and well known method of producing cultures prior to his claimed invention. The base or carrying medium of the Bond inoculant as disclosed and claimed in the patent in suit was likewise well known and not claimed as any invention of the patentee.

13.

The broad basis or theory of the claimed invention
1161 or discovery disclosed and claimed in the Bond patent in suit is the placing in a common base or carrying medium two or more different species of bacteria with the result that one species in the composite culture produces or has no effect on the other species in the matter of the fixation of nitrogen in the host plant when applied as an inoculant. This is stated by the patentee in the patent itself as follows:

> "It has heretofore been considered impractical to prepare a composite inoculant containing organisms which will cause nodulation on more than one of the cross inoculation groups. This has not been done because it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented." (See lines 70-75, column 1 and lines 1-4, column 2, page 2, of Bond patent in suit.)

14.

The Court finds that the fact of inhibition or lack of inhibition is a work of nature and nothing that the patentee did or disclosed in his patent brought about this state of inhibition or lack of inhibition in the composite culture of the patent. The patentee ascertained by well known routine tests the existence or nonexistence of this inhibitive characteristic.

15.

The Court further finds that all of the claims in issue of the Bond patent in suit relied upon by the Plaintiff do not involve the invention or discovery of "any new and useful art, machine, manufacture or composition of matter" within the contemplation of the patent laws of the United States.

16.

While the foregoing Findings of Fact are sufficient to dispose of the case, the Court further finds that the product sold by the Defendant of record, Funk Brothers Seed Company, and manufactured by the Agricultural Laboratories, Inc. under the trademark or trade name of "Legume-Aid" is a composite inoculant for leguminous plants consisting of a plurality of selected cultures of bacteria, comprising at least two species or strains of bacteria of the genus Rhizobium, which do not affect one another in their
1162 respective abilities to fix nitrogen in association with leguminous plants for which each species or strain is specific.

17.

The Court further finds that in the composite inoculant of the make of The Agricultural Laboratories, Inc. sold by the Defendant of record here, the number of bacteria put in the common base or carrying medium was approximately ten million of the alfalfa bacteria per standard unit and fourteen million of clover bacteria per standard unit.

18.

The Court further finds as a matter of fact that if the claims in issue of the Bond patent in suit relied upon by

the Plaintiff as infringed, to wit, claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 were valid in law, the accused composite culture sold by the Defendant of record Funk Brothers Seed Company, under the trade mark or name "Legume-Aid" would constitute an infringement of each and all of said claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 of said Bond patent in suit No. 2,200,532.

19.

The Court further finds that prior to the claimed invention of the Bond patent in suit substantial portions of the available literature indicated that mixed cultures for field legumes were generally unsatisfactory and that different strains or species of the Rhizobium bacteria exhibited an inhibitory effect on each other when mixed in a common base or carrier, that Mr. Bond believed in the existence of this inhibitory effect at the time he instituted his research and acted in complete good faith when he stated in his application for the patent in suit that it had been considered impractical to prepare a composite culture inoculant which would cause nodulation on more than one of the cross inoculation groups because it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic fixation by the plant and the organism was inhibited or even prevented, and that plaintiff is not guilty of the charge of unclean hands.

1163

20.

The Court further finds that while the thought or general idea of the desirability of a composite culture was suggested to the patentee Bond by the witness Myron E. Lusk, the discovery of the concrete means of the solution of the problem, if any, was the act of the patentee Varley Sherman Bond and the invention or discovery, if any, was the sole act of said patentee and the said Myron E. Lusk was not a co-inventor.

21.

The Court furthef finds that in view of the finding of the claimed invention of the Bond patent in suit as to the claims in issue being not patentable invention, it is not

considered necessary to pass upon the questions or issues of the prior art patents, publications, uses and knowledge constituting any anticipation.

22.

The Court further finds that the Plaintiff limited its charges of infringement in this proceeding to those arising under claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 and the Court finding that each and all of these claims are invalid under the patent statute of the United States, the other claims of the Bond patent in suit are, therefore, not at issue, with the result that the Defendant is not entitled to any relief by way of declaratory judgment concerning said other claims under the counterclaim of the Defendant.

CONCLUSIONS OF LAW

1.

From all of the above the Court concludes as a matter of law that the Bond patent No. 2,200,532 as to each and every of the claims thereof in suit herein, to-wit, claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 are null and void as not involving any invention or discovery of any new and useful art, machine, manufacture or composition of matter.

2.

That the Bond patent No. 2,200,532 as to each and every of the claims thereof in suit herein, to wit, claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 do not disclose patentable invention.

3.

That the remaining claims of said Bond patent No.
1164 2,200,532 to wit, claims 2, 9, 10, 11 and 12 are not at issue in these proceedings.

4.

That the Defendant, Funk Brothers Seed Company, is entitled to a judgment or decree dismissing Plaintiff's com-

plaint for want of equity as to each and all of the claims of the Bond patent in suit No. 2,200,532 in issue herein, to wit, claims 1, 3, 4, 5, 6, 7, 8, 13 and 14.

5.

That the Plaintiff, Kalo Inoculant Company, is entitled to a judgment or decree dismissing the counterclaim of the Defendant herein as to the remaining claims of the Bond patent No. 2,200,532, to wit, claims 2, 9, 10, 11 and 12 thereof, as not involving any justiciable issue under the Federal Declaratory Judgment Act.

6.

That the Defendant, Funk Brothers Seed Company, is entitled to have and recover from the Plaintiff two-thirds of the costs to be taxed by the Clerk of the Court, the balance of the costs to be taxed against defendant.

(signed) Chas. G. Briggle,
United States District Judge.

Endorsed, Filed,
October 10, 1945,
G. W. Schwaner, Clerk.

1165 And afterwards, to-wit: on the 10th day of October 1945, A. D. 1945, the following further proceedings were had in said Court in said cause and were entered of record, to-wit:

1166 IN THE DISTRICT COURT OF THE UNITED STATES,
For the Southern District of Illinois
Southern Division

Kalo Inoculant Company, Plaintiff, *vs.* Funk Brothers Seed Co., Defendant.	Civil Action No. Q-62

JUDGMENT

This cause having come on to be heard on the pleadings and proof and the Court having taken the same under advisement and having made and filed herein special Findings of Fact and Conclusions of Law:

And now upon the foregoing Findings of Fact and Conclusions of Law filed herein it is

ORDERED, ADJUDGED AND DECREED

1. That the Bill of Complaint herein be and the same hereby is dismissed on the merits for want of equity.

2. That the counterclaim of the Defendant filed herein be and the same hereby is dismissed as not involving any justiciable issue between the parties hereto under the Federal Declaratory Judgment Act, not otherwise disposed of.

3. That the costs herein be taxed two-thirds against plaintiff and one-third against defendant.

Dated this 10th day of October, 1945.

(signed) Chas. G. Briggle
United States District Judge

Endorsed, Filed,
October 10, 1945,
G. W. Schwaner, Clerk.

1167 And afterwards, to-wit: on the 2nd day of January, 1946, there was filed in the office of the Clerk of said Court in said cause a certain Notice of Appeal which said Notice of Appeal was and is in the words and figures following, to-wit:

1168 IN THE DISTRICT COURT OF THE UNITED STATES
For the Southern District of Illinois
Southern Division

Kalo Inoculant Company, Plaintiff, *vs.* Funk Brothers Seed Co., Defendant.	Civil Action No. Q-62

NOTICE OF APPEAL

Notice is hereby given that Kalo Inoculant Company, Plaintiff, hereby appeals to the United States Circuit Court of Appeals for the Seventh Circuit from the judgment entered in this action on October 10, 1945.

A bond for costs on appeal is filed herewith.

(signed) Chester A. Groves,
Attorney for Plaintiff
W.C.U. Building, Quincy, Illinois
(signed) J. Bernhard Thiess
(signed) Sidney Newman
(signed) M. Hudson Rathburn
Of Counsel
77 W. Washington Street,
Chicago, Illinois.

Endorsed, Filed,
January 2, 1946,
G. W. Schwaner, Clerk.

1169 And afterwards, to-wit: on the 8th day of February, A. D. 1946, there was filed in the office of the Clerk of said Court in said cause a certain Plaintiff's Statement of Points on Its Appeal which said Plaintiff's Statement of Points on its Appeal was and is in the words and figures following, to-wit:

1170 IN THE DISTRICT COURT OF THE UNITED STATES
Southern District of Illinois
Southern Division

Kalo Inoculant Company, a corporation, Plaintiff, *vs.* Funk Brothers Seed Company, a corporation, Defendant.	Civil Action No. Q-62

PLAINTIFF'S STATEMENT OF POINTS ON ITS APPEAL

The Kalo Inoculant Company, plaintiff, hereby states that the following are the points involved on its appeal from the judgment on its complaint herein:

1. The Court erred in finding that all of the claims in issue of the Bond patent in suit do not involve the invention or discovery of "any new and useful art, machine, manufacture, or composition of matter" within the contemplation of the patent laws of the United States.

2. The Court erred in not finding that all of the claims in issue of the Bond patent in suit relied upon by the plaintiff involve the invention or discovery of a new and useful composition of matter within the contemplation of the patent laws of the United States.

3. The Court erred in not finding that claims 13 and 14 of the Bond patent in suit are not limited to a composition of matter or composite culture containing mutually non-inhibitive strains of root nodule bacteria.

1171 4. The Court erred in concluding as a matter of law that the Bond patent, as to each and every one of the claims in suit, to wit, claims 1, 3, 4, 5, 6, 7, 8, 13 and 14, is null and void as not involving any invention or discovery of any new and useful art, machine, manufacture or composition of matter.

5. The Court erred in concluding that the Bond patent, as to each and every one of the claims thereof in suit, to wit, claims 1, 3, 4, 5, 6, 7, 8, 13 and 14, does not disclose patentable invention.

6. The Court erred in not finding and concluding that all of the claims in issue of the Bond patent in suit, to wit, claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 are good and valid in law.

7. The Court erred in dismissing plaintiff's Complaint for want of equity.

(signed) Thiess, Olson & Mecklenburger
Attorneys for Plaintiff.

Receipt of a copy of the foregoing Statement of Points on appeal is hereby acknowledged this 31st day of January, 1946.

(signed) Toulmin & Toulmin
Attorneys for Defendant.

Endorsed, Filed,
February 8, 1946,
G. W. Schwaner, Clerk.

1172 And afterwards, to-wit: on the 2nd day of January, A. D. 1946, there was filed in the office of the Clerk of said Court in said cause a certain Bond for Costs which Bond for Costs was and is in the words and figures following, to-wit:

1173 UNITED STATES DISTRICT COURT
Southern District of Illinois
Southern Division

Kaló Inoculant Company, Plaintiff, *vs.* Funk Brothers Seed Company, Defendant.	Civil Action No. Q-62

BOND FOR COSTS

Know All Men by These Presents that Kalo Inoculant Company, an Illinois Corporation, as principal, and Hartford Accident and Indemnity Company, a corporation of the State of Connecticut, as surety, are held and firmly bound unto Funk Brothers Seed Company, an Illinois corporation, in the full and just sum of Two Hundred Fifty Dollars ($250.00) to be paid to the said Funk Brothers

Seed Company, its successors or assigns, to which payment well and truly to be made, we bind ourselves, our successors and assigns, jointly and severally, by these presents.

Sealed with our seals and dated this 27th day of December, 1945.

Whereas, on the 10th day of October, 1945, in an action in the United States District Court for the Southern District of Illinois, Southern Division, between Kalo Inoculant Company, as plaintiff, and Funk Brothers Seed Company, as defendant, a judgment was entered against the Kalo Inoculant Company dismissing its complaint on the Bond patent No. 2,200,532, dated May 14, 1940, and taxing two-thirds of the costs against the plaintiff, and the said Kalo Inoculant Company has filed a notice of appeal to the
1174 United States Circuit Court of Appeals for the Seventh Circuit from said judgment.

Now, the condition of this obligation is such that if the Kalo Inoculant Company shall prosecute its appeal to effect and shall pay all its costs on said appeal if said appeal is dismissed, or if the judgment from which said plaintiff appeals is affirmed, or such costs as the Circuit Court of Appeals may award if the judgment from which said plaintiff appeals is modified, then this obligation shall be void; otherwise to remain in full force and effect.

Kalo Inoculant Company
(seal) By (signed) M. E. Lusk
Its President

Hartford Accident and Indemnity Company
By (signed) Frank J. Souhey
Attorney in Fact
(seal)

Endorsed, Filed,
January 2, 1946,
G. W. Schwaner, Clerk.

1175 And afterwards, to-wit: on the 8th day of January, A. D. 1946, there was filed in the office of the Clerk of said Court in said cause a Certain Notice of Cross-Appeal which said Notice of Cross-Appeal was and is in the words and figures following, to-wit:

1176 IN THE DISTRICT COURT OF THE UNITED STATES
For the Southern District of Illinois
Southern Division

Kalo Inoculant Company, a corporation, Plaintiff, *vs.* Funk Brothers Seed Company, a corporation, Defendant.	Civil Action No. Q-62

NOTICE OF CROSS-APPEAL

Notice is hereby given that Funk Brothers Seed Company, Defendant, hereby cross-appeals to the United States Circuit Court of Appeals for the Seventh Circuit, from such portions of the judgment entered in this action on October 10, 1945, as constitute an aggrievement of Defendant, to-wit:

1. As to so much of the judgment directed to a finding that the accused product sold by the Defendant, did constitute an infringement of each and all of the claims in suit if the said claims were valid in law.

1177 2. As to so much of the judgment directed to a finding that it is not considered necessary to pass upon the questions or issues of the prior art patents, publications, uses and knowledge, constituting any anticipation of the Bond patent, in view of the finding of invalidity of the claims in suit on other grounds.

3. As to so much of the judgment directed to a finding that the Defendant is not entitled to any relief by way of Declaratory Judgment under the counterclaim of the Defendant.

A bond for costs on cross-appeal is filed herewith.

(signed) Toulmin & Toulmin
Attorneys for Defendant.

(signed) H. A. Toulmin, Jr.
(signed) D. C. Staley
(signed) David Davis
(signed) Harold W. Lewis
Solicitors and Of Counsel
for the Defendant.

Endorsed, Filed,
January 8, 1946,
G. W. Schwaner, Clerk.

1178 And afterwards, to-wit: on the 6th day of February, A. D. 1946, there was filed in the office of the Clerk of said Court in said cause a certain Statement of Points to be Relied Upon by the Defendant-Appellant on Cross-Appeal of this Action which said Statement of Points was and is in the words and figures following, to-wit:

1179 IN THE DISTRICT COURT OF THE UNITED STATES
Southern District of Illinois
Southern Division

Kalo Inoculant Company, a corporation, Plaintiff,	Civil Action No. Q-62
v.	
Funk Brothers Seed Company, a corporation, Defendant.	

STATEMENT OF POINTS TO BE RELIED UPON BY THE DEFENDANT-APPELLANT ON CROSS-APPEAL OF THIS ACTION.

Now comes the Defendant, Appellee; and Appellant on cross-appeal, Funk Brothers Seed Company, and pursuant to Rule 75(d) of the Federal Rules of Civil Procedure and Rule 9(1) of the Rules of the Circuit Court of Appeals for the Seventh Circuit, files this, its statement of points on which it intends to rely on the cross-appeal in this case.

1. The District Court erred as a matter of law in finding and holding that the product sold by the Defendant of record, Funk Brothers Seed Company, and manufactured by Agricultural Laboratories, Inc. under the trade-mark or trade-name of "LEGUME-AID" is a composite inoculant for leguminous plants consisting of a plurality of selected cultures of bacteria, comprising at least two species or strains of bacteria of the genus Rhizobium of different cross-inoculation groups which
1180 do not affect one another in their respective abilities to fix nitrogen in association with leguminous plants for which each species or strain is specific.

2. The District Court erred as a matter of law in finding and holding that as a fact there exists in nature mutually inhibitive and mutually non-inhibitive strains of Rhizobium bacteria.

3. The District Court erred as a matter of law in its finding and holding that if the claims in issue of the Bond patent in suit, #2,200,532, relied upon by the Plaintiff as infringed, to wit, claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 were valid in law, the accused composite product sold by the Defendant of record under the trade-mark or trade-name "LEGUME-AID" would constitute an infringement of each and all of the said claims.

4. The District Court erred as a matter of law in failing to find and hold that if the claims in issue of the Bond patent in suit, #2,200,532, relied upon by the Plaintiff as infringed, to wit, claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 were valid in law, the accused composite product sold by the Defendant of record under the trade-mark or trade-name "LEGUME-AID" would not constitute any infringement of either or all of said claims.

5. The District Court erred as a matter of law in holding that since the Plaintiff limited its charges of infringement to those arising under claims 1, 3, 4, 1181 5, 6, 7, 8, 13 and 14 of the Bond patent #2,200,532, that the other claims of the Bond patent in suit are, therefore, not at issue in the proceedings, whereas he should have held all of the claims of the patent to be invalid.

6. The District Court erred as a matter of law in failing to find and hold that claims 2, 9, 10, 11 and 12 of the Bond patent in suit, #2,200,532 are at issue in the proceedings, and were invalid.

7. The District Court erred as a matter of law in finding and holding that since all of the claims placed at issue by the Plaintiff, to wit, claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 are declared to be invalid under the Patent Statute of the United States, that the Defendant is not entitled to any relief by way of declaratory judgment concerning other claims of the patent in suit under the counterclaim of the Defendant.

8. The District Court erred as a matter of law in holding that the Plaintiff is entitled to a judgment or decree dismissing the counterclaim of the Defendant as to claims 2, 9, 10, 11 and 12 as not involving any justici-

able issue under the Federal Declaratory Judgment Act.

9. The District Court erred as a matter of law in failing to find and hold that the claims of the Bond patent in suit, #2,200,532, not specifically placed at issue by the Plaintiff, to wit, claims 2, 9, 10, 11 and 12, in-
1182 volve justiciable issues under the Federal Declaratory Judgment Act under the counterclaim of the Defendant and in failing to pass upon such issues.

10. The District Court erred as a matter of law in dismissing the counterclaim of the Defendant under the Federal Declaratory Judgment Act as to any or all of the claims of the patent in suit.

11. The District Court erred as a matter of law in dismissing the counterclaim of the Defendant under the Federal Declaratory Judgment Act as to any or all of the claims of the patent in suit without passing upon the questions or issues of the prior art patents, publications, uses and knowledge constituting anticipation of the patent in suit, and in not holding that all the claims in the patent in suit were invalid.

12. The District Court erred as a matter of law in not passing upon the questions or issues of the prior art patents, publications, uses and knowledge constituting anticipation of the patent in suit in view of Defendant's counterclaim under the Federal Declaratory Judgment Act.

13. The District Court erred as a matter of law in finding and holding that in view of the finding that the claimed invention of the Bond patent in suit, as to the claims in issue being not patentable invention, it is not considered necessary to pass upon the questions or issues of the prior art patents, publications, uses
1183 and knowledge constituting any anticipation of the patents in suit.

14. The District Court erred as a matter of law in dismissing the counterclaim of the Defendant as not involving any justiciable issue between the parties under the Federal Declaratory Judgment Act.

15. The District Court erred as a matter of law in finding and holding that the patentee Bond had reason to believe in the existence of the inhibitory effect between different strains or species of the Rhizobium bacteria and acted in complete good faith when he stated in his application for the patent in suit that it had been con-

sidered impractical to prepare a composite inoculant which would cause nodulation on more than one of the cross-inoculation groups because it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented, and that Plaintiff is not guilty of the charge of unclean hands, and in failing to find and hold that the patentee did not act in complete good faith when he made the aforementioned statements, and that Plaintiff is guilty of the charge of unclean hands.

16. The District Court erred as a matter of law in finding and holding that while the thought or general idea of the desirability of a composite culture was suggested to the patentee Bond by the witness, Myron
1184 E. Lusk, the discovery of the concrete means of the solution of the problem, if any, was the act of the patentee Varley Sherman Bond, and the invention or discovery, if any, was the sole act of the patentee, and in failing to find and hold that the said Myron E. Lusk was a co-inventor of the invention or discovery, if any, and the patent to be invalid in law as the result thereof.

Respectfully submitted,
(Signed) Toulmin & Toulmin
Attorneys for Defendant.

Receipt of a copy of the foregoing Statement of Points on Cross-appeal is hereby acknowledged this 4th day of February, 1946.

(Signed) Thiess, Olson & Mecklenburger
Attorneys for Plaintiff.

Endorsed, filed,
February 6, 1946,
G. W. Schwaner, Clerk.

1185 And afterwards, to-wit: on the 8th day of January, 1946, there was filed in the office of the Clerk of said Court in said cause a certain Cost Bond on Cross-Appeal which said Cost Bond on Cross-Appeal was and is in the words and figures following, to-wit:

1186 IN THE DISTRICT COURT OF THE UNITED STATES
For the Southern District of Illinois
Southern Division

Kalo Inoculant Company, a corporation, Plaintiff, v. Funk Brothers Seed Company, a corporation, Defendant.	Civil Action No. Q-62

COST BOND ON CROSS-APPEAL.

KNOW ALL MEN BY THESE PRESENTS, that we, Funk Brothers Seed Company, an Illinois corporation, with its principal place of business in Bloomington, Illinois, as principal, and The Indemnity Insurance Company of North America, a corporation, organized and existing under the laws of the State of Pennsylvania, with its principal place of business in Philadelphia, Pennsylvania, and duly authorized to transact a general surety business in the State of Illinois, as surety, are held and firmly
1187 bound unto Kalo Inoculant Company, an Illinois corporation, with its principal place of business in Quincy, Illinois, its attorneys, executors, administrators, successors or assigns, in the full and just sum of Two Hundred Fifty ($250) Dollars, to which payment, well and truly to be made, we bind ourselves, our successors, executors, administrators or assigns, jointly and severally by these presents.

Sealed with our seals and dated this 7th day of January, 1946.

WHEREAS, lately on October 10, 1945, in an action depending in the United States District Court for the Southern District of Illinois, Southern Division, between Kalo Inoculant Company, Plaintiff, and Funk Brothers Seed Company, Defendant, a final judgment or decree was rendered against the said Kalo Inoculant Company, and the said Kalo Inoculant Company, having filed a Notice of Appeal from such judgment or decree to the United States Circuit Court of Appeals for the Seventh Circuit,

pursuant to Rule 73 of the Federal Rules of Civil Procedure; and the said Funk Brothers Seed Company having filed a Notice of Cross-Appeal from such portions of said judgment or decree as constitute an aggrievement of Defendant, to the United States Circuit Court of Appeals for the Seventh Circuit;

1188 Now, the condition of this obligation is such, that if the said Funk Brothers Seed Company shall prosecute its cross-appeal to effect and shall answer all charges and costs that may be awarded against it, if it fails to make its cross-appeal good, then the above obligation is to be void; otherwise in full force and effect.

FUNK BROTHERS SEED COMPANY.
By (signed) Toulmin & Toulmin
Attorneys
THE INDEMNITY INSURANCE COMPANY OF NORTH AMERICA
By (signed) Wallace E. Stafford
Attorney-in-Fact.

(Seal)

Endorsed, Filed,
January 8, 1946,
G. W. Schwaner, Clerk.

1189 And afterwards, to-wit: on the 8th day of February, A. D. 1946, there was filed in the office of the Clerk of said Court in said cause a certain Stipulation which said Stipulation was and is in the words and figures following, to-wit:

1190 IN THE DISTRICT COURT OF THE UNITED STATES
Southern District of Illinois
Southern Division

Kalo Inoculant Company, a corporation, Plaintiff, *vs.* Funk Brothers Seed Company, a corporation, Defendant.	Civil Action No. Q-62

STIPULATION.

It is stipulated and agreed, by and between counsel for the parties in the above-entitled cause, subject to the approval of this Honorable Court, that the time within which the Plaintiff-Appellant and the Defendant-Appellee; Appellant on cross-appeal, may file the record on appeal and docket the appeal in this case pursuant to Rule 73(g) may be and hereby is extended to and inclusive of March 4, 1946.

(signed) Thiess, Olson & Mecklenburger
(signed) M. Hudson Rathburn
Attorneys for Plaintiff
(signed) Toulmin & Toulmin
(signed) H. A. Toulmin, Jr.
(signed) D. C. Staley
Attorneys for Defendant

Approved this 8th day of February, 1946.
(signed) Chas. G. Briggle
United States District Judge
Endorsed, Filed Feb. 8, 1946
G. W. Schwaner, Clerk.

1191 And afterwards, to-wit: on the 11th day of February A. D. 1946, there was filed in the office of the Clerk of said Court in said cause a certain Stipulation which said Stipulation was and is in the words and figures following, to-wit:

1192 IN THE DISTRICT COURT OF THE UNITED STATES
Southern District of Illinois
Southern Division

Kalo Inoculant Company, a corporation, Plaintiff, *vs.* Funk Brothers Seed Company, a corporation, Defendant.	Civil Action No. Q-62

STIPULATION.

It is hereby stipulated and agreed, by and between counsel for the parties in the above-entitled cause, this Honorable Court approving, that the Clerk shall, for the purposes of the appeals now pending herein, transmit to the Circuit Court of Appeals the original exhibits and the original typewritten transcript of the testimony in lieu of copies thereof.

(signed) Thiess, Olson & Mecklenburger
Attorneys for Plaintiff
(signed) Toulmin & Toulmin
Attorney for Defendant

February 11th, 1946.

IT IS SO ORDERED:
(signed) Chas. G. Briggle
United States District Judge

Endorsed, filed,
February 11, 1946.
G. W. Schwaner, Clerk.

1193 And afterwards, to-wit: on the 25th day of February, A. D. 1946, there was filed in the office of the Clerk of said Court in said cause a certain Stipulated Designation of Record on Appeal which said Stipulated Designation of Record on Appeal was and is in the words and figures following to-wit:

1194 IN THE DISTRICT COURT OF THE UNITED STATES
Southern District of Illinois
Southern Division

Kalo Inoculant Company, a corporation, Plaintiff, *vs.* Funk Brothers Seed Company, a corporation, Defendant.	Civil Action No. Q-62

STIPULATED DESIGNATION OF RECORD ON APPEAL.

It is hereby stipulated and agreed, by and between the parties hereto, that for the purposes of the appeal and cross-appeal, heretofore taken in the above-entitled cause, to the United States Circuit Court of Appeals for the Seventh Circuit, that the Transcript of Record to be made up and forwarded to the said Circuit Court of Appeals by the Clerk shall include the following pleadings, papers, documents, testimony and exhibits:

1. Caption. (Usual form)
2. Complaint filed December 10, 1943.
3. Defendant's Answer to Complaint and Defendant's Counterclaim filed January 26, 1944.
4. Plaintiff's Reply to Defendant's Counterclaim filed February 14, 1944.
5. Defendant's Amended Answer to Complaint filed October 28, 1944.
6. Order entered April 30, 1945, setting case for trial at Quincy, Illinois, on May 28, 1945.
7. Order entered May 14, 1945, resetting case for trial at Quincy, Illinois, on June 25, 1945.

1195 8. Stipulation filed June 25, 1945, re use of uncertified copies of patents and publications.

9. Stipulation re claims of Bond patent in suit relied on by plaintiff.
10. The typewritten transcript of the evidence and proceedings including only pages 62 to 824, inclusive.
11. The following original exhibits to be filed with the transcript under Rule 10(5) of the Court of Appeals:

Plaintiff's Exhibits 1 to 7, inclusive, and 10 to 22, inclusive

Defendant's Exhibits 1, 3 to 11, inclusive, 13 to 17, inclusive, and 19 to 36, inclusive

12. Court's Memorandum of Holdings.

13. Findings of Fact and Conclusions of Law, entered October 10, 1945.

14. Judgment entered October 10, 1945.

15. Notice of Appeal by plaintiff filed January 2, 1946.

16. Bond on Plaintiff's Appeal.

17. Notice of Cross Appeal by Defendant, filed January 8, 1946.

18. Bond on Defendant's Cross Appeal.

19. Statement of Points intended to be urged on its appeal by Kalo Inoculant Company, appellant, filed herewith.

20. Statement of Points intended to be urged on its cross appeal by Funk Brothers Seed Company, cross appellant.

21. This stipulated designation.

1196 22. Any further stipulation between the parties hereto concerning the record on these appeals or the time for the docketing thereof and any and all orders of the Court with regard thereto.

(signed) Thiess, Olson & Mecklenburger
Attorneys for Plaintiff

(signed) Toulmin & Toulmin
Attorneys for Defendant

Endorsed, Filed,
February 25, 1946,
G. W. Schwaner, Clerk.

770-771

May 14, 1940. V. S. BOND 2,200,532

BACTERIAL INOCULANT FOR LEGUMINOUS PLANTS

Filed Aug. 24, 1938

Fig 1

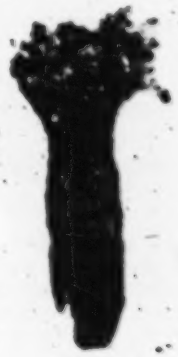

Fig 2

Fig 3

Fig 4

INVENTOR.
Varley Sherman Bond
BY Thiess, Olson & Buckenberger
ATTORNEYS.

PLPS. EX. 2 IDEN.

Patented May 14, 1940 2,200,532

D

UNITED STATES PATENT OFFICE

2,200,532

BACTERIAL INOCULANT FOR LEGUMINOUS PLANTS

Varley Sherman Bond, Quincy, Ill., assignor to Kalo Inoculant Company, Quincy, Ill., a corporation of Illinois

Application August 24, 1938, Serial No. 226,565

14 Claims. (Cl. 71—7)

This invention relates to a bacterial culture and more specifically to a bacterial culture useful for the inoculation of the seeds of leguminous plants.

It is well known that certain plant species of the genus Leguminosae may under certain conditions fix nitrogen directly from the air and convert it to organic nitrogenous compounds. The mechanism of this nitrogen fixation is not understood at the present time, but it has been known for a number of years that it can only be carried out when the plant grows in symbiotic relationship with certain bacteria of the genus Rhizobia. Plants belonging to the genus Leguminosae which are capable of symbiotic relationship with the Rhizobia are peas, beans, alfalfa, red clover, white clover, vetch, lupines, and the like. The bacteria infect the roots of these plants in the soil and cause the formation of so-called nodules, in which it is presumed that the nitrogen fixation in the plant occurs.

Other plants that are important in agriculture, such as the grasses and grains, are not able to fix nitrogen from the air. They depend entirely upon the combined nitrogen in the soil, such as nitrates and ammonium salts, for their nitrogen requirements. Consequently, the combined nitrogen in the soil becomes depleted after a series of crops consisting only of the non-nitrogen fixers have been grown therein. It has consequently become customary in many districts to practice crop rotation, whereby the plants that are capable of fixing nitrogen in the soil will enrich the soil with combined nitrogen, whereby nitrogenous nutrients are provided for a succeeding crop of non-nitrogen fixing plants. More recently it has become the practice to plant mixed crops, which comprise a mixture of the nitrogen fixing and the non-nitrogen fixing variety. Nitrogen is thus supplied to the soil in a combined form which may be readily utilized by the non-nitrogen fixing plants.

Bacteria of the genus Rhizobia which are capable of infecting leguminous plants so that nitrogen may be fixed are widely spread in nature. They are not, however, universally present in soil and it has been found desirable to inoculate the seeds of leguminous plants with a culture of bacteria of the genus Rhizobia previous to the planting of the seeds in the field. This inoculation insures that micro-organisms of the correct species will be present in the soil whereby the leguminous plant may become infected. In the absence of such infection as pointed out above, no nitrogen fixation occurs within the plant. The inoculation of seeds is particularly desirable where it is desired to plant them in a soil that has not grown a plant of the same species for a number of years. In order to insure a maximum amount of nitrogen fixation and development of the leguminous plant, it is always desirable to inoculate the seeds previous to the planting thereof.

Figure 1 shows a root portion of a red clover plant bearing nodules A which were produced by infection with *Rhizobium trifolii*. This view was taken with permission of the authors from a photograph reproduced in the monograph Root Nodule Bacteria and Leguminous Plants, by Fred, Baldwin and McCoy, University of Wisconsin Studies in Science, No. 5, 1932.

Fig. 2 shows a group of forty red clover plants after ten weeks' development in a sterile nitrogen-free sand culture which was not inoculated previous to the time of planting.

Fig. 3 shows a group of forty-one red clover plants of the same age and number grown in the same nitrogen-free substrata as those in Fig. 2, but wherein the seeds were inoculated with a culture of *Rhizobium trifolii* previous to planting.

Fig. 4 is the same as Fig. 3 but wherein the seeds were inoculated with a composite culture prepared in accordance with one embodiment of this invention.

It was discovered early that all species of the genus Rhizobia would not infect all of the plants of the genus Leguminosae to produce nodules wherein the nitrogen fixation presumably takes place. Thus certain species of bacteria are specific to certain species of Leguminosae. The group of plants that will be infected by a single species of bacteria has come to be known in the art as a cross-inoculation group. There are at least six well-recognized species of Rhizobium which will infect six fairly well-defined cross-inoculation groups of plants. *Rhizobium meliloti* will infect alfalfa and white or yellow sweet clovers; *Rhizobium trifolii* will infect red, white, crimson or mammoth clovers; *Rhizobium leguminosarum* will infect garden or field peas, vetch, and broad beans; *Rhizobium phaseoli* will infect garden or field beans; *Rhizobium lupini* will infect the lupines; and *Rhizobium japonicum* will infect the soy beans. The above groups are the most important in regard to inoculation of the seeds of field crops previous to sowing. There is a mixed group, including cow peas, lespedeza, peanuts, velvet beans, lima beans and crotalaria, which has not been well enough defined with re-

spect to cross-inoculation to be assigned a definite terminology. This latter group, however, have been relatively unimportant for the preparation of commercial bacterial inoculants for the seeds of leguminous plants.

A number of so-called commercial cultures of bacteria have appeared on the market from time to time which were purported to be useful for producing nodulation of the roots of the leguminous plants. Many of these cultures have been very effective and useful for the purpose for which they were to be employed. These cultures have appeared in a large variety of forms and contain a large number of viable strains of the desired organism. They have been distributed on suitable jelly bottle slants or in a wet or dry carrying material such as sand, soil, or charcoal.

A variety of methods have also been employed for producing the bacterial inoculant for commercial distribution. In the preparation of an inoculant or culture in accordance with one method, the carrying media, such as humus or charcoal, may be inoculated with a suitable strain of the organism, and sugar, mineral salts, and water may be added with subsequent development of the species of organism therein. The resulting material is then packaged and distributed in any desired manner. This is known as the simple humus culture, but is not entirely satisfactory since it is usually desirable to at least partially sterilize the humus or other carrying material previous to inoculation with the Rhizobia culture in order to insure that the distributed organism will develop within the material to such an extent that a suitable number of organisms would be produced sufficient to inoculate the seeds to be treated. Furthermore, a large amount of metabolic products of the organisms were formed directly in the culture, which do not provide a healthy environment for the organisms, and a large percentage have a tendency to die off in a relatively short time.

A second method that has been employed for the preparation of commercial inoculants has been to develop the organism in a liquid culture and, after the development of the organism in the liquid, mix the liquid with the desired amount of carrying material such as humus or charcoal. This method again has the disadvantage that the metabolic products of the organism and the residual sugars and protein of the culture medium are introduced directly into the commercial product as distributed, which tends to cause deterioration of the culture and the death of a large proportion of the organisms contained therein.

All of the cultures that have been successfully used in the past for the inoculation of the field leguminous plants, such as clover, alfalfa, soy beans, and the like, have contained only one species of the organism. Thus, for inoculation of soy beans, it has been the practice to use a bacterial inoculant comprising substantially a pure culture of *Rhizobium japonicum* in order to obtain maximum plant yield and maximum nitrogen fixation. The same is true with respect to the inoculation of the seeds of the plants belonging to the various other cross-inoculation groups which have been indicated above.

It has heretofore been considered impracticable to prepare a composite culture inoculant containing organisms which will cause nodulation on more than one of the cross-inoculation groups. This has not been done because it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented. For this reason it has been considered desirable to use a culture containing a single species of organism rather than one containing a mixture.

The use of a single species of bacteria in a culture presents a serious difficulty in the manufacture and distribution of bacterial inoculants, since it is therefore necessary to distribute a separate culture contained in a separate package for the inoculation of seeds of plants belonging to the various cross-inoculation groups. This situation is further complicated by the fact that the cultures as distributed are ordinarily usable for only a certain length of time after preparation, since the organisms in the culture tend to die out on storage of the culture on the shelves of the distributor. It has consequently become the practice among the distributors of bacterial inoculants of this character to replace cultures free of charge that are unused and over about one year old.

At the present time there are on the market many so-called "pasture mixtures" of seeds which comprise a mixture of seeds including those of different species of leguminous plants. There are distributed in comparatively small quantities, and heretofore the farmer seldom takes the trouble to inoculate the mixture with the several separate bacterial cultures necessary for the seeds of each cross-inoculation group in the pasture mixture.

One object of this invention is to provide a method for the preparation of an inoculant for the seeds of a leguminous plants which will contain a large number of micro-organisms and will retain their viability over a long period of time.

A further object of this invention is to provide a method for introducing a culture of bacteria into a suitable carrying material within which the inoculant is distributed.

A further object of this invention is to provide a mixed culture of Rhizobia capable of inoculating the seeds of plants belonging to several cross-inoculation groups and having the same efficiency in respect to nitrogen fixation as a culture which contains only a single species of the organism.

A further object of this invention is to provide a mixed culture the component strains of which are selected in such a manner that optimum efficiency results when the organisms are combined into a single culture.

A still further object of this invention is the provision of a bacterial culture prepared in admixture with a fine powdered inert material in a new and novel manner.

A further object of this invention is to provide an inoculant for the so-called "pasture mixture" which comprises efficient nitrogen fixing strains of different species of Rhizobia combined in one culture.

Further and additional objects of this invention will appear from the following detailed description, the drawing, and the appended claims.

In order to prepare an inoculant in accordance with one embodiment of this invention, the desired species of organism may be inoculated in any desired manner onto the surface of a suitable agar or jelly culture medium and allowed to grow for a period of several days. A quantity of water may then be added with thorough shaking and further growth permitted, after which time the resulting suspension may be incorporated with a

suitable carrying medium such as humus, charcoal, soil, fine sand, and the like. The bacterial inoculant prepared in accordance with this general method contains an enormous number of organisms which will remain viable over a long period of time. The inoculant is easily handled and may be readily packed in cans or other containers for distribution to the farmer. If the carrying material employed is black humus or charcoal, the inoculant has a further advantage in that it may be readily determined whether or not it has been thoroughly mixed with the seeds previous to inoculation.

In order that this invention may be more readily understood, a specific example is presented in order to more definitely point out the method of preparation of the inoculant. A suitable and preferably pure culture of a bacterial species is selected. It may be obtained by direct isolation from the nodules of a leguminous plant according to methods that are well known in the art. Suitable methods are described by Fred, Baldwin and McCoy, supra, and in the Laboratory Manual of General Microbiology, by Fred and Waksman, 1928. The organism may be cultivated on a yeast extract-sucrose agar which may contain the following ingredients:

Agar	grams	15.0
Sucrose	do	10.0
Dipotassium phosphate	do	0.5
Magnesium sulfate	do	0.2
Sodium chloride	do	0.1
Calcium carbonate	do	1.0
Calcium gluconate	do	1.5
Yeast water (pH 6.8)	cc	50
Tap water	cc	950

The yeast water infusion in the above formula may be prepared as suggested by Fred and Waksman, supra, page 16, as follows: Two kilograms of fresh starch-free pressed yeast are added to 10 liters of tap water. The mixture is steamed for three to four hours at 95° to 100° C. with occasional stirring. The resulting mass is sterilized in an autoclave in deep layers for a period of about one hour. The sterilized material is allowed to stand for about one week, and, if undisturbed, the yeast cells will settle to the bottom and leave a clear straw-colored liquid above. The clear infusion may then be siphoned off and the reaction adjusted to pH 6.8 to 7.0. This clear infusion is the yeast water referred to in the above formula.

The ingredients of the medium are mixed together and sterilized in the usual manner. The calcium carbonate may be sterilized separately and added to the sterile medium after it has cooled down in order to prevent the decomposition of sucrose during the heating period. The medium prepared in accordance with the formula given above is a jelly on the surface of which cultures of the Rhizobia may readily develop under aerobic conditions. It may be also prepared in the liquid form by eliminating the agar.

The desired culture of the Rhizobia may be inoculated onto an agar slant of the medium and incubated at suitable temperatures for a time to permit development of the culture on the surface of the agar. This first transfer of the culture is generally made in test tubes. After a suitable period of incubation, the culture may then be transferred by a sterile needle or loop from the test tubes to an agar slant in a 200 cc. flat bottle containing about 30 cc. of slanted agar media. Here the organism is again permitted to develop for a suitable incubation period at 28° to 30° C., which in most cases will extend from a few days to over a week. The culture grown on the agar surface of the bottle may then be aseptically washed from the surface with sterile water according to recognised bacteriological technique whereby a suspension of the organisms is produced. This suspension, being quite heavy and almost opaque, may be used for the inoculation of slanted agar media contained in a plurality of still larger bottles such as one liter bottles. These bottles may contain about 125 cc. of the agar medium described above. The inoculation may be made by streaking with a needle or aseptically spraying a water suspension of the organisms onto the surface of the agar by an atomizer or any suitable spraying means. It is desirable that aseptic conditions be maintained throughout the process until after the large bottles have been inoculated with a pure culture of the organism. Prevention of contamination up to this point is desirable, since the contaminating organism may outgrow the desired species of the Rhizobia, thus negativing the effect of the culture for seed inoculation purposes.

After the culture has developed on the surface of the agar in the large bottles for a suitable length of time (from about 2 to 10 days), tap water may be added in order to fill the bottles about half full. They are thoroughly agitated and the agar is cut or broken with a suitable metal probe, whereby the bacteria are rinsed from the surface of the agar and the agar becomes thoroughly broken up in the bottom of the bottle. It may be desirable, but it is not necessary, to employ sterile water for this purpose. The growth of the Rhizobia has taken place to such an extent that any chance contaminant will readily be suppressed by the large numbers of the Rhizobia.

After the agar has been thoroughly broken up, the large bottles are allowed to further incubate at suitable temperatures for a period of a few days. It has been found that the number of the organisms becomes very greatly increased during this subsequent period of incubation. The agar may then be separated from the suspension of organisms by passing the suspension through a suitable filter or screen. A four mesh screen has been found to be satisfactory. The bottles and agar may be washed with a small quantity of tap water. The resulting filtered suspension of bacteria is very heavy, being milk-like in appearance. This suspension may then be thoroughly incorporated with any desired amount of humus, which serves as a carrying means for the organism of the suspension. The humus and suspension mixture is allowed to stand for about 12 to 24 hours before the material is packed in order to permit complete absorption of the moisture by the humus. The resulting composition may then be packaged in moisture-proof fiber cans or other suitable containers for shipment.

The material from seventy-two one liter bottles inoculated and treated as described above is sufficient to inoculate about ninety kilograms of humus in order that the concentration of organisms in the humus will be approximately sixty million per gram. The final product may contain about 45% moisture. The water content may be adjusted by adding water in the desired proportions previous to packaging.

It will be understood, of course, that other types of media may be employed for the development of the organism preliminary to its inoculation into the humus or other carrying material, and the proportions of the various ingredients may be varied within a wide latitude. Likewise, charcoal,

fine sand, soil, kieselguhr, and other materials may also be used as the carrying medium. If humus is employed, it may be desirable to neutralize its natural acidity with hydrated lime or calcium carbonate. It is not necessary, as has been previously stated, that sterile conditions be maintained after the incubation period on the surface of the agar immediately preliminary to the addition of the excess water. Sterile conditions are not necessary after this point, since the organisms have increased to such large numbers that they will suppress any type of contaminating organism that may be introduced. Likewise, it is not necessary to sterilize the humus or other carrying material because of the tremendous number of organisms of the desired type that are introduced therein. It will be readily recognized, however, that, if desired, strict aseptic conditions may be maintained up until the time the material is packaged in the containers for shipment.

The culture prepared in accordance with this method contains a sufficient number of organisms so that 150 grams will inoculate about one bushel of small seed.

It will be understood from the above description that the number of organisms incorporated into the humus may be readily predetermined by means of a Petroff-Hausser bacterial counter or other suitable direct counting apparatus. This method, therefore, has the advantage that the number of organisms being introduced into the final inoculant may be readily determined. The final culture is also comparatively free of excess sugar and minerals, since they are retained to a large extent by the agar in the large bottles. Consequently, additional nutrient is not introduced into the humus which may stimulate the development of contaminating organisms.

It will be understood also that the incubation period at the different stages of preparation of the culture previous to inoculating into the carrying means depends on many factors recognized by one skilled in the art. Thus, the character of the media, the temperature of incubation, and the species of Rhizobium are factors to be considered.

In order to inoculate the seeds of leguminous plants by the inoculant prepared in accordance with the above given description, the seed, within about twenty-four hours previous to the time of planting, is slightly moistened and a predetermined quantity of the inoculant is thoroughly mixed therewith in order to provide the desired concentration of organisms on the seed. The distribution of the inoculant throughout the seeds may be readily observed because of the black color of the humus with which the inoculant is prepared. The inoculant prepared in accordance with this invention may be satisfactorily used for a period of more than one year and sufficient organisms remain viable during this time in order to provide a number satisfactory for thorough inoculation.

As has been pointed out above, composite cultures for inoculating the seeds of leguminous plants have not generally come into use because of the inhibitory effect that certain strains of certain species of the Rhizobia have on each other and also because no method has been developed whereby a composite culture may be produced wherein a sufficient number of each species of organism in the inoculant is insured.

In order to more clearly point out the nature and magnitude of the inhibitory effect of several species of Rhizobia, tests were carried out using strains of various organisms which were picked at random and unselected in the manner to be hereinafter described. Thus a culture of *Rhizobium japonicum* which was known to be an efficient culture for fixing nitrogen when in association with the soybean plant was tested in order to determine its nitrogen fixing efficiency when inoculated onto soybean seeds in the presence of *Rhizobium trifolii* and *Rhizobium meliloti*. The tests were made by growing the appropriate plants in sterilized nitrogen-free sand according to well known methods in the art and fully set forth by Fred and Waksman, supra, and Fred, Baldwin and McCoy, supra. Three groups of soybean plants containing eight plants in each group were planted in a nitrogen-free sand containing suitable mineral salts and according to the standard methods. One group of seeds were planted sterile, being uninoculated. The seeds of the second group were inoculated with a single strain of the species of *Rhizobium japonicum* indicated above. The third group of seeds was inoculated with a mixture of the same strain of *Rhizobium japonicum* and strains of *Rhizobium trifolii* and *Rhizobium meliloti*. The seeds were permitted to germinate and the plants were grown in the sand for a period of fifty-six days. The eight plants developing from each group were then analyzed for total nitrogen by a suitable Kjeldahl procedure. The plants of the first group (uninoculated) contained a total of 79 milligrams of nitrogen. The plants of the second group (single strain) contained 246 milligrams of nitrogen. The plants of the third group (same strain mixed with strains of other species) contained only 203 milligrams of nitrogen. Consequently the plants of the second group fixed 167 milligrams of nitrogen over the control, and the plants of the third group only fixed 124 milligrams of nitrogen over the control. Thus it will be seen that this strain of *Rhizobium japonicum* produced 34.8% more nitrogen when employed alone than when employed in the presence of strains of other species of Rhizobia.

In the same manner a strain of *Rhizobium trifolii* which efficiently fixed nitrogen in the presence of the host plant alone was tested. Groups of forty plants were inoculated in this instance in the manner indicated above which is well recognized in the art. It was found that this unselected strain of *Rhizobium trifolii* caused about 118% more nitrogen to be fixed in the host plant when employed alone as an inoculant than when in the presence of other species of the Rhizobia, such as *Rhizobium japonicum* and *Rhizobium meliloti*.

It is possible, in accordance with one embodiment of this invention, to produce an effective composite inoculant containing a plurality of species of organisms which is capable of infecting a variety of leguminous plants belonging to a plurality of cross-inoculation groups.

In general, the composite culture may be prepared by selecting strains of the desired species of the Rhizobia which will produce optimum beneficial results to the host plant and will not be adversely affected by each other. The strains, after having been selected, may be cultivated in a manner which has been described above on agar or jelly media separately, the heavy suspension of each organism being introduced directly into the humus or other carrying material in the manner that has been previously described.

In order to produce a composite inoculant

containing, for example, *Rhizobium meliloti*, *Rhizobium trifolii*, and *Rhizobium japonicum*, which inoculant will infect the corresponding cross-inoculation groups, a number of strains of each of these organisms may be isolated from nature by any of the approved methods such as have been described in the above referred to Laboratory Manual of General Microbiology by Fred and Waksman. Each of the strains are tested separately with its own host plant in order to select out those which are most effective in respect to the development of the host plant and the quantity of nitrogen fixed thereby. These tests may be made according to standard practice by aseptically growing the plants in a nitrogen-free substrata such as sand containing mineral salts. The cultures showing the best results in association with the host plant may then be selected and the various strains of the different species may be mixed together in order to determine if the nitrogen-fixing ability of one species is adversely affected by the mere presence of another, as has been previously thought to be the case. Thus, it has been previously considered that the nitrogen-fixing ability of *Rhizobium trifolii* in symbiotic relationship with red clover is markedly inhibited if strains of *Rhizobium meliloti*, *Rhizobium japonicum*, or other species of the Rhizobia were present within the same inoculant. It has been found, however, that, by a suitable process of selection of strains in the manner indicated above, a composite culture may be obtained which may be used to infect a plurality of cross-inoculation groups with optimum results.

The organisms of the genus Rhizobium which are mutually noninhibitive may be designated by the term alpha. No method has been observed whereby the alpha strains of the organisms may be differentiated from the mutually inhibitive group of Rhizobia other than by making actual nitrogen fixation tests by inoculating the various host plants with the proposed mixture of the Rhizobia. A composite culture that is satisfactory for use for inoculating seeds of alfalfa, red clover, and/or soy beans (representatives of three cross-inoculation groups) contains a mixture of *Rhizobium meliloti alpha*, *Rhizobium trifolii alpha*, and *Rhizobium japonicum alpha*. All of the strains may be selected so as to be mutually noninhibitive when mixed and used for seed inoculation. It will, of course, be recognized that certain inhibitive strains may be employed in the mixture. In general, however, it is desirable to use the alpha strains which have been selected in the manner proposed in the above. By the alpha strains, which have been designated herein, is meant those strains of the species of Rhizobia which are mutually noninhibitive of each other as regards nitrogen fixation in the host plant. It is understood that the alpha strains of each species may vary somewhat from each other in minor physiological, morphological and/or immunological characteristics. All such variants may be included within the scope of the term alpha strain.

One criterion by which the alpha strains of the organisms may be determined is based on a statistical comparison of the total milligrams of nitrogen fixed in plants previously inoculated with a single strain unmixed with strains of other species with the total milligrams fixed in plants inoculated with the same strain mixed with strains of other species. In making such tests the conditions for inoculation and growth of the plants should be kept uniform when testing both the mixed culture and the single strain. The method for carrying out tests for determining the amount of nitrogen fixed by leguminous plants in association with the various species of the Rhizobia are well known in the art and are given in detail by Fred and Waksman, supra, and Fred, Baldwin and McCoy, supra.

Each culture may be tested by inoculating a given number of seeds of the proper host plant with a strain of culture of bacteria to be tested either singly or mixed with other species of the Rhizobia. The seeds may then be planted in jars containing sterile sand and appropriate nitrogen-free mineral salt solutions capable of supporting plant growth. The same number of seeds are planted in each of five jars for each culture being tested, and the total number of milligrams of nitrogen fixed by the plants in each of the five jars is tested. The standard deviation of the mean amount of nitrogen fixed in each jar may then be determined by appropriate statistical methods. If the mean plus or minus the standard deviation of the nitrogen content of plants inoculated with a strain used unmixed with the strains of another species, overlaps the mean plus or minus the standard deviation of plants inoculated with the same strain used mixed with other species of Rhizobia, that strain may be considered as nonantagonistic or an alpha strain within the meaning of this invention.

For the preparation of a composite bacterial inoculant in accordance with this invention, heavy suspensions of selected cultures of *Rhizobium trifolii alpha*, *Rhizobium meliloti alpha*, and *Rhizobium japonicum alpha* may be prepared in the same manner as has been indicated above for the preparation of a single culture in accordance with this invention. The heavy suspensions may then be mixed and introduced into the humus in concentrations suitable to give the desired results.

In order that 90 kilograms of dry humus may be properly inoculated with the three organisms indicated above, about 19 liters are prepared of each suspension in the manner previously indicated. The concentration of organisms in the suspension may be about 900 million per cubic centimeter for *Rhizobium meliloti alpha* and *Rhizobium trifolii alpha* and about 450 million per cubic centimeter for *Rhizobium japonicum alpha*. The suspensions may be introduced into the humus or other carrying material separately or may be mixed before introduction. The humus, after inoculation with the three organisms (about 57 liters of composite suspension), may be passed through a suitable mechanical mixer in order to thoroughly incorporate the organisms within the humus or carrying material. The water content of the humus may be brought up to about 45% and the mass is permitted to stand for about 12 to 24 hours preliminary to packaging in order to permit a more thorough absorption of the water and bacterial cultures into the humus. This latter storage period also causes the humus to become lighter and more easily handled by the packing machines, which may be of any desired kind. One hundred seventy-five grams of this inoculant is sufficient to inoculate one bushel of red clover or alfalfa seed or two bushels of soy bean seed.

The resulting composite inoculant may be used for inoculating the seeds of leguminous plants in the same manner as hereinbefore set forth. It

may be used with good results for inoculating the seeds of any of the plants included within the cross-inoculation groups represented by the bacterial species present. The particular example given has included *Rhizobium trifolii alpha*, since it has been generally thought that *Rhizobium trifolii* was particularly sensitive to other of the Rhizobia in respect to its ability to fix nitrogen within the host plant. It has been found, however, that, by suitable selecting, strains of the organism may be found from which a composite inoculant may be produced having all of the desirable qualities of a single strain culture with the further additional advantages previously indicated.

It will be understood that this invention is not to be limited to the above described method for producing a composite inoculant. It is not necessary that it be prepared as set forth in the manner described above. Any inoculant comprising a mixture of selected anti-inhibitive strains of ordinarily inhibitive organisms of the Rhizobia group is included within the spirit and scope of this invention.

In order that a more definite understanding may be had of the advantages to be derived from the use of a composite culture selected and prepared in accordance with this invention, a series of tests were made by planting red clover seeds in half gallon jars containing sterile sand supplemented with all essential minerals except nitrogen, and were inoculated as indicated below. After ten weeks of growth in the greenhouse under identical conditions, the sand was washed from the roots of the plants, the plants dried, weighed and ground and samples were analyzed by the Kjeldahl method for their nitrogen content.

Each group or series of seeds was planted in a series of five jars and the standard deviation between the jars of each culture series was determined. Each series was inoculated as follows:

1. Uninoculated control plants.
2. Plants inoculated with a non-selected strain of *Rhizobium trifolii* in single culture unmixed with other species.
3. Plants inoculated with a selected, non-antagonistic strain of *Rhizobium trifolii alpha* in single culture unmixed with other species.
4. Plants inoculated with same organism as series 2 in admixture with other species of the Rhizobia.
5. Plants inoculated with the same organism as series 3 in admixture with other species of Rhizobia.

The following table is presented which indicates the inoculant used for each series of plants, the dry weight of ten plants, the per cent of nitrogen in the dry material, the milligrams of nitrogen present per ten plants, and the milligrams of nitrogen fixed per ten plants:

Inoculant series No.	Grams dry weight per 10 plants	Percent nitrogen	Mg. nitrogen per 10 plants	Mg. nitrogen fixed per 10 plants
1	0.61	1.07	6.5±0.8*	.....
2	4.18	2.92	122.0±10.8*	115.5±10.0*
3	4.00	2.85	131.0±16.6*	124.5±15.8*
4	3.58	2.20	80.5±4.7*	72.2±3.9*
5	4.50	2.88	126.0±40.5*	119.5±39.7*

*Standard deviation of the mean of a series of 5 jars.

It will be observed that the nitrogen fixing efficiency of the inoculants of series 2, 3 and 5 are high and substantially the same. When the non-selected strain, however, was mixed with other species of Rhizobia the amount of nitrogen fixed by the host plant was seriously impaired as indicated by series 4. This example clearly shows the increase in effectiveness of a mixed culture which contains an alpha strain over that which contains a non-selected but otherwise efficiently nitrogen fixing strain. It is pointed out here that the mean plus or minus the standard deviation of the nitrogen fixed by series 4 does not fall in the same range as the mean plus or minus the standard deviation of that fixed by series 2. Series 3 and 5 do overlap in this respect and the strain of *Rhizobium trifolii* employed in those tests was consequently an alpha strain according to the one criterion that has been previously described.

It is to be understood that this invention is not to be limited to the selection of a single strain which is to be used in the composite culture. All of the strains may be selected in the manner indicated previous to the preparation of the inoculant. Furthermore, if desired, a plurality of strains of the same species may be introduced into the composite culture containing several species. This practice has been found to be desirable in many instances in order that there will be double insurance that an effective nitrogen fixing strain of the specific organism is present within the culture.

Referring more particularly to the drawing,

Fig. 1 is a photolithograph picture of a root system of a red clover plant having nodules A located near the crown of the root. Large nodules on the plant near the crown are indicative of good nitrogen fixation and a good strain of the organism.

Fig. 2 shows a control group of forty red clover plants which have grown in a nitrogen-free sand culture for ten weeks with no Rhizobia present. This group had a wet weight of 20.4 grams and total nitrogen content of 27 milligrams derived from the original seeds. No nitrogen was fixed.

Fig. 3 shows the forty-one plants grown under identical conditions as those shown in Fig. 2 but which were inoculated with a humus inoculant containing only bacteria of the species *Rhizobium trifolii alpha* prepared in accordance with this invention. The wet weight of this group of plants was 156.7 grams and had a total nitrogen content of 645 milligrams of nitrogen. Thus 618 milligrams of nitrogen were fixed.

Fig. 4 shows a group of forty plants the same as Fig. 3 which were inoculated with a composite inoculant prepared in accordance with one embodiment of this invention containing strains of the species *Rhizobium trifolii alpha*, *Rhizobium meliloti alpha*, and *Rhizobium japonicum alpha*. It will be noted that the red clover plants inoculated with the composite inoculant containing the alpha strains are fully developed to the same extent as the one inoculated with the pure culture and no inhibition is observed in the plant development because of the presence of the other organisms. The wet weight of this group was 159.0 grams and had a total nitrogen content of 662 milligrams. Thus 635 milligrams of nitrogen were fixed.

It will be observed that the organisms of the composite culture described in the foregoing example may be introduced into the culture in any desired numbers and the relative proportion may be fairly accurately predetermined by means of direct bacterial count. The cultures are not mixed until immediately preliminary to their introduction into the carrying material and after

they have developed to substantially their maximum numbers. Consequently, there is no danger of one species overgrowing the other during the process of incubation.

The invention is not to be limited in any way to the number of organisms contained within the inoculant or the number necessary for inoculating a predetermined quantity of seed. In practice, and as shown herein, a large excess of bacteria is generally introduced into the carrying material in order to insure that all of the seeds are thoroughly inoculated with a sufficient number of organisms to produce the desired results.

While several particular embodiments of this invention are shown above, it will be understood, of course, that the invention is not to be limited thereto since many modifications may be made, and it is contemplated, therefore, by the appended claims to cover any such modifications as fall within the true spirit and scope of this invention.

I claim:

1. An inoculant for leguminous plants comprising a plurality of selected cultures of different species of bacteria of the genus Rhizobium, one of said cultures being *Rhizobium trifolii alpha*, said cultures being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

2. A bacterial inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium comprising *Rhizobium trifolii alpha*, *Rhizobium meliloti alpha*, and *Rhizobium japonicum alpha*.

3. An inoculant for leguminous plants comprising humus and a mixture of species of bacteria of the genus Rhizobium, said mixture containing a strain of *Rhizobium trifolii alpha*.

4. An inoculant for leguminous plants comprising a plurality of selected mutually non-inhibitive strains of different species of bacteria of the genus Rhizobium, said strains being unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

5. An inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium, at least one of which strains is unaffected by the others in respect to its ability to fix nitrogen in the leguminous plant for which it is specific.

6. An inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium, the bacteria of each strain being present in numbers of substantially the same order of magnitude, said strains being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

7. A bacterial inoculant for leguminous plants comprising a moist powder base and a plurality of selected mutually non-inhibitive strains of different species of bacteria of the genus Rhizobium including *Rhizobium trifolii*, the bacteria of each strain being present in numbers of substantially the same order of magnitude, said strains being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

8. A bacterial inoculant for leguminous plants comprising a moist powder base containing a substantially negligible concentration of bacterial nutrients and a plurality of strains of different species of bacteria of the genus Rhizobium, at least one of which strains is unaffected by the others in respect to its ability to fix nitrogen in the leguminous plant for which it is specific.

9. A method for producing a bacterial inoculant for leguminous plants which comprises separately selecting strains of different species of the genus Rhizobium, separately cultivating said strains in nutrient media, and mixing the resulting cultures whereby a composite inoculant is produced, said strains originally being selected so that they are substantially non-inhibitive and non-antagonistic to each other in respect to their ability to fix nitrogen in the host plant for which they are specific.

10. A method for producing a composite inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium, which comprises cultivating each strain separately in suitable culture medium to produce a substantial quantity of living organisms and thereafter mixing the organisms with a moist powder base containing a substantially negligible concentration of bacterial nutrients whereby the desired inoculant is formed.

11. A method for producing a composite bacterial inoculant for leguminous plants which comprises separately cultivating a plurality of strains of bacteria selected from different species of the genus Rhizobium and subsequently mixing the resulting cultures containing large numbers of bacteria with a moist powder base containing a substantially negligible concentration of bacterial nutrients whereby the desired inoculant is obtained, the bacteria of each strain being present in numbers of substantially the same order of magnitude.

12. A method for producing a composite inoculant for leguminous plants which comprises separately cultivating a plurality of species of bacteria of the genus Rhizobium in separate cultures and mixing with a powder base predetermined numbers of the bacteria of each culture to produce the desired inoculant, said powder base being substantially free of added bacterial nutrients.

13. A bacterial inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium in numbers of substantially the same order of magnitude incorporated with a powder base, the mixture being substantially free of bacterial nutrients whereby growth of the bacteria therein is inhibited.

14. The inoculant as defined in claim 13 wherein one of said species is *Rhizobium trifolii*.

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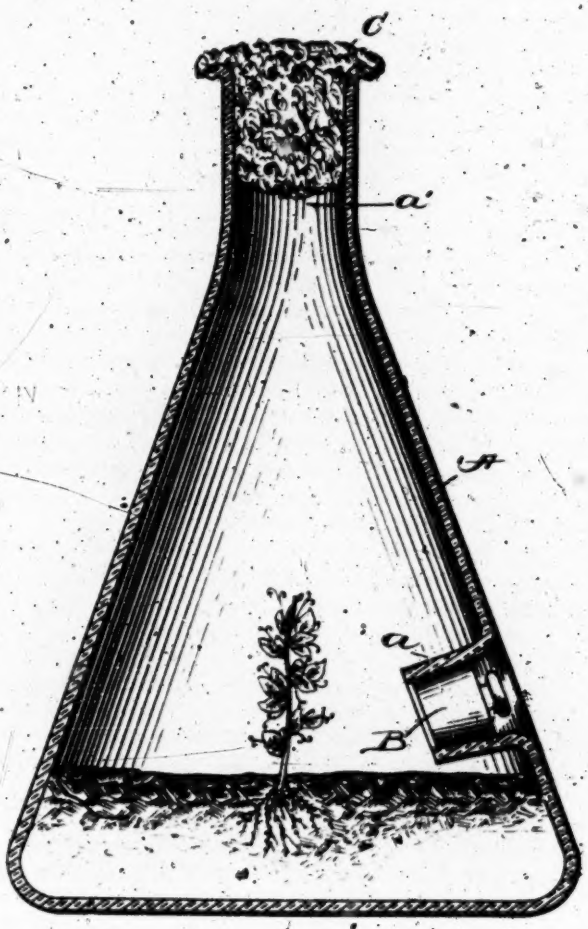
ART OF GROWING AND DISTRIBUTING NITRO GATHERING BACTERIA.

APPLICATION FILED JAN. 17, 1907.



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UNITED STATES PATENT OFFICE. 782-783

GEORGE HERBERT EARP-THOMAS, OF TORONTO, ONTARIO, CANADA.

ART OF GROWING AND DISTRIBUTING NITRO-GATHERING BACTERIA.

No. 865,965. Specification of Letters Patent. Patented Sept. 10, 1907.

Application filed January 17, 1907. Serial No. 352,768.

To all whom it may concern:

Be it known that I, GEORGE HERBERT EARP-THOMAS, a citizen of New Zealand, residing at 400 Bloor street, Toronto, Canada, have invented certain new and useful Improvements in the Art of Growing and Distributing Nitrogen-Gathering Bacteria; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to improvements in the art of growing and distributing nitrogen gathering bacteria.

It is known that certain bacteria which live at the roots of plants have the power of collecting nitrogen from the air and supplying it to the said plants. It is also known that it is advantageous to grow cultures of such nitrogen gathering bacteria in laboratories and distribute the same to agriculturists in order that they may directly inoculate the seeds before planting, whereby an increased growth of the plants and an increased yield is obtained. In growing such cultures in the laboratory it has been the practice heretofore first to obtain some of the desired bacteria from plants taken from the field or garden and then to implant such bacteria so obtained upon a suitable medium which is then kept under the desired conditions to propagate the colonies, the culture thus obtained being generally known as the stock culture, which laboratory stock culture serves as a source of germs from which to propagate the cultures to be distributed to the agriculturists. Unfortunately, the process of obtaining a satisfactorily pure culture direct from plants growing in the field or garden is a tedious and slow procedure, because of the difficulty of excluding contaminations, such as molds, yeasts and soil bacteria of a kind other than that desired. It might seem that once a pure culture of the desired bacteria had been obtained that there would never be any further need to go again to the growing plant for the germs, but that from the stock culture other cultures might be propagated indefinitely. However, owing to the fact that the characteristic properties of these bacteria become modified by the food upon which they live, it results that a laboratory stock culture, after some time, consists of bacteria which have, to a certain extent, lost their power of fixing nitrogen for the plant, or in other words have become what is known as attenuated, that is to say, less virulent than before and therefore less valuable to the farmer for inoculating seed than a freshly prepared stock culture. Therefore, under the present methods, it is customary to discard the stock culture from time to time and make a fresh one from the virile bacteria of the soil grown living plant.

It is one of the objects of my invention to avoid the above described disadvantage, and this I do by the means more fully explained hereinafter.

There is also a further great disadvantage connected with the old method, which is due principally to the necessity for the frequent renewal of the stock culture and to the great similarity which exists between the nitrogen gathering bacteria and other soil bacteria which are useless for inoculating seed. This disadvantage is that when a new culture has been made, if it be examined under the microscope, it may appear to be the desired nitrogen gathering bacteria and yet really may be some form of soil bacteria useless for the purpose required. Apparently the only really reliable test of a culture is to put it in practical use, that is, to inoculate seed with it and then grow a plant from such seed. This test has been employed heretofore, but under such conditions as often to render the test inconclusive, for the reason that the possibility of the inoculation of the plant from sources other than the stock culture, was not absolutely excluded. Consequently, by the old method of procedure it is possible to have cultures of bacteria satisfactorily pass all the tests to which they have been submitted and be sent to the farmer as nitrogen-gathering bacteria, when in fact they were not nitrogen gathering bacteria but were merely some other form of bacteria which were useless for the purpose intended.

It is a further object of my invention to avoid this disadvantage, which I do by the means hereinafter explained.

Furthermore, although the nitrogen gathering bacteria so far generally known are supposed to be and probably are of one species only, the results attained in actual practice have shown that there is a difference in the bacteria dependent upon the species of plant upon which the stock culture was obtained. For example, bacteria obtained originally from the roots of red clover will not produce as satisfactory results when employed for inoculating alsike as would bacteria originally obtained from the roots of an alsike plant, and on the other hand the latter will not be satisfactory for the inoculation of red clover. Apparently the characteristics of the bacteria are modified by the food upon which they live, so that when for example, the red clover bacteria are placed upon red clover seed they are ready to thrive on the roots of the growing plant, whereas when placed upon some other seed, as for example, on alsike seed, they find their environment and food less suitable to them and hence are not as vigorous in their attacks on the plant roots. However, the bacteria have the power of finally adapting themselves to the changed conditions, that is to say, after many generations are produced upon the new kind of host the race finally becomes accustomed to the new host and is enabled to carry on its function satisfactorily. Unfortunately, this adaptation of the bacteria to its strange host requires some time, and the consequence is that seed inoculated

with bacteria unadapted to it does not have the advantage of a quick growth when first starting and thus a part of the growing season is lost, which would not be the case were the proper kind or variety of bacteria present on the seed at the moment of germination. Owing to this necessity for employing the proper kind of bacteria for each kind of plant, it has been necessary to maintain many different kinds of stock cultures in the laboratory each containing bacteria adapted for a particular plant. Also it has been necessary first to ascertain from a purchaser, the kind of plant which he intended to inoculate before his order could be filled. And as it is necessary to make up the cultures in distributing packages prior to the opening of the season for which they are to be used, so that orders may be filled without delay, it has been necessary to make a supply of distributing packages of each kind of bacteria.

It is a further object of my invention to avoid this difficulty which I do by the means hereinafter described.

With these general objects in view, and some others which will be obvious to those skilled in the art from the description hereinafter, my invention consists in the features and details which will first be described in connection with the accompanying drawing and then particularly pointed out in the claims.

The drawing is an elevation of a stock culture embodying one part of my invention.

Referring to the drawing, A is a receptacle or container, in this case of suitable transparent material, as for example, glass, and provided with an opening at one side arranged to be closed by a suitable closure. In the present example, the desired result is attained by providing the receptacle with a tubulature indicated at *a* which may be closed by a stopper which will exclude germs, as for example, a tightly fitting glass stopper B.

The upper part of the receptacle A is provided with means for supplying it with sterilized air that is to say air which is free from germs of any kind. In the present instance, I obtain this result in a simple manner by providing the receptacle A at the upper part with an opening, *a'* in which may be inserted a filtering device for filtering the air so that all germs will be removed as the outside air passes through the filter into the receptacle A. As a filter a plug of cotton is generally employed, this being indicated at C.

Within the receptacle, I place a suitable medium, taking care to have both sterilized by any well known methods, the medium in the preferred form of my invention being non-nitrogenous and substantially transparent. In my Patent 816,850, dated April 3, 1906, I have described a medium which is very suitable for this purpose. In this medium, I place one or more seeds taken from the desired kind of plant in such a way as to insure that the seed is free from bacteria of any kind. For the purpose of accomplishing this result I may proceed in the following manner. I take a seed-head of the desired plant and carefully sterilize the same by passing it several times through the flame, such as the flame of an alcohol lamp, in order to make certain that all organisms on the outside of the seed-head are destroyed by the heat. The seeds themselves within their seed cases or pods are not injured by the heat if the work is properly done. Apparently there are no injurious germs within the seed-pod, if the latter is perfect, that is, if it has not been punctured, whereby it results that the sterilization of the exterior of the seed-head in a manner such as described will enable the operator to remove the seeds from their pods by means of suitable sterilized instruments and transfer the same under the usual aseptic laboratory conditions, to the medium in the receptacle. Thereafter, the medium may be inoculated with the desired culture of nitrogen gathering bacteria, through the tubulature. The receptacle thus prepared may be placed in a suitable situation in order to receive a proper amount of light and heat, whereby the seed germinates and the bacteria at once start to work in the rootlets.

The medium being non-nitrogenous, the bacteria are compelled to obtain their entire supply of nitrogen from the atmosphere. The plant in turn takes its nitrogen from the bacteria and thus grows rapidly, a little sterilized water being added to the medium from time to time as may be required. As the bacteria are growing and multiplying upon their natural host, they have a vitality and obtain a virulency which is even greater than that of the bacteria living upon a plant growing under natural conditions in earth. Furthermore, as the medium is transparent the development of the colonies may be watched and the growth of the plant itself serves to determine whether the bacteria in the medium are the true nitrogen gathering bacteria or not for if they are not the plant will not thrive, whereas if they are the plant will flourish and will develop tubercles on the roots. Such a laboratory stock culture being once established there will be no need thereafter to go to the original source for bacteria, namely, to the soil grown plant, because there is not only no loss in virulency of the bacteria on a stock culture such as I have described, but if anything an increase above the average of those cultures made directly from the soil-grown plant. When now it is desired to make other cultures from the described stock culture it is only necessary to remove the stopper from the tubulature, insert a sterilized pair of forceps and remove a tubercle from the roots of the plant which may then be used in any desired manner to inoculate the new medium. The bacteria thus obtained are in a most virulent form and absolutely reliable. The danger of contamination is substantially eliminated and the new cultures are produced quickly and with certainty.

Although I have referred above to the use of the tubercle for inoculating a fresh medium from the stock culture, it is also possible to use some other portion of the root of the plant, as for example, a piece of one of the small root hairs, for these also contain some bacteria.

While I have hereinabove described the receptacle and its contents as a stock culture, it is also to be understood that when a stock culture is obtained by the old method, my invention may be employed as a means for testing such stock culture. That is, the seed may be planted in the medium in the receptacle

just as hereinbefore described and then inoculated not to serve as a stock culture, but merely to determine whether or not the bacteria employed are of the proper kind. For such a purpose the receptacle may be smaller, because it is not necessary to provide such room for the plant. The first growth of the plant will finish the test and determine whether the bacteria are of the desired kind or not. In preparing these test cultures, it is advisable to make the medium as transparent as possible and the receptacle may be small enough so that it can conveniently be examined under the microscope. I have found an ordinary test tube with a plug of cotton in its open end to serve satisfactorily. With such test cultures it is possible to observe the bacteria at work upon the plant. This test is particularly useful in exposing to view the nitrogen gatherers which enter the roots but for some reason do not form nodules. These bacteria are often sufficiently energetic and numerous to aid the plant without any external evidence of their presence being visible.

In order to be prepared to fill all orders which may be received for cultures to inoculate the various kinds of plants which it is customary to inoculate, a series of stock cultures each with a different species of plant growing therein may be prepared and kept on hand. The distributing vessels may be prepared and filled with medium, inoculated and sealed in the manner described in my said Patent 816,850 each distributing vessel being inoculated with its own kind of bacteria from the desired stock culture. However, I have found that it is an important improvement upon the process set forth in said patent to proceed as follows: After the distributing vessel has been sterilized, supplied with a semi-solid or rather substantially solid sterilized medium, inoculated and incubated in the manner described in my said patent, a small portion of sterilized water should be poured on top of the medium and the receptacle then closed, as for example, by hermetically sealing the same; whereupon the distributing package is ready for shipment or storage.

The advantage of the solid medium is that there is less danger of spilling the same in handling the vessels prior to sealing and hence less care is required in placing them in the incubator. But the foremost advantage is that the growth of the colonies may be observed with a solid medium whereas it cannot with a liquid medium. The advantage of the liquid medium is that the bacteria can subdivide more readily than in a semi-solid medium, and hence will propagate quicker. Therefore, by following the process set forth above, I attain the advantage of a solid medium during the period of preparation of the cultures prior to sealing and yet also attain the advantage of the liquid medium after sealing, thus leaving the bacteria in a favorable condition for a further development during storage and shipment.

In the above description, I have assumed that the medium in the distributing vessels is inoculated with one kind only of the nitrogen gathering bacteria. However, an important feature of my invention consists in inoculating the medium in each distributing vessel with a plurality of kinds of nitrogen gathering bacteria, as will now be more fully explained. To do this, I first form a composite colony of a plurality of kinds of bacteria, by inoculating some medium in a suitable vessel with cultures taken separately from the different stock cultures, thus combining in one culture bacteria suitable for different kinds of plants. After this composite stock culture has been formed, the distributing vessels are inoculated from it whereby instead of each distributing vessel containing only one kind or variety of the nitrogen gathering bacteria, it contains a plurality of kinds. Consequently, such a culture is suitable for use in inoculating the seed of anyone of the kinds of plant from which the bacteria were originally obtained. However, and this is an important feature of my invention, it is not necessary to use as much if any larger quantity of such a composite culture in inoculating the seed than is required with the simple culture, for the reason that there is enough of the specific kind of bacteria to attack the rootlets at the time the seed germinates and thus start the young plant into rapid growth by which time the other kinds of bacteria have adapted themselves to their changed conditions and then can thrive on the plant roots and assist in the growth of such plant. A further advantage of this plan is that it gives a means of graduating the intensity of the attack on the young rootlets of the germinating seed while at the same time, insuring the presence of sufficient bacteria to properly stimulate the growth of the plant after it has arrived at a more vigorous stage.

From laboratory experiments, I have ascertained that it is possible to injure instead of aid the germinating plant by the employment of too large a colony of virulent bacteria during the germinating of the seed. In fact, in experiments carried out by me with peas, the bacteria had not only retarded the growth of the rootlets but had actually reduced the pea seed to a mere husk or shell. All danger from this source is entirely avoided by the use of the composite culture.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. The process of developing a bacteriological culture, which consists in growing in a medium a plant inoculated with the desired bacteria while excluding all contaminations from said plant and medium.

2. The process of developing a bacteriological culture, which consists in growing in a non-nitrogenous medium, a plant inoculated with nitrogen gathering bacteria while excluding all contaminations from said plant and medium.

3. The process of developing a bacteriological culture, which consists in growing a plant inoculated with the desired bacteria within a germ proof inclosure.

4. The process of developing a bacteriological culture, which consists in growing a plant inoculated with the desired bacteria, within a germ proof inclosure, while maintaining a restricted supply of sterilized air to said inclosure.

5. The process of developing a bacteriological culture, which consists in growing a plant inoculated with the desired bacteria within a transparent germ proof inclosure.

6. The process of developing a bacteriological culture, which consists in growing, in a substantially transparent medium, a plant inoculated with the desired bacteria while excluding all contaminations from the plant and medium by a transparent germ proof inclosure.

7. The process of developing a bacteriological culture, which consists in planting, in a sterilized medium, within a germ proof inclosure, a vital seed free from contaminating germs maintaining a supply of sterilized air to said inclosure and supplying sterilized water to the plant.

8. The process of developing a bacteriological culture, which consists in growing a plant inoculated with the desired bacteria, within a germ proof inclosure, and then inoculating a medium with a portion of the roots of said plant.

9. The process of developing a bacteriological culture, which consists in growing a plant inoculated with the desired bacteria, in a medium within a germ proof inclosure and then inoculating another medium with a portion of the roots of said plant.

10. The process of developing a bacteriological culture, which consists in growing a plant, inoculated with the desired bacteria, within a germ proof inclosure, removing a nodule from said plant and inoculating a medium with the same.

11. The process which consists in preparing a composite culture consisting of a plurality of kinds of nitrogen gathering bacteria, then inoculating seed with such composite culture and planting the seed.

12. The process which consists in inoculating seed with a composite culture consisting of a plurality of kinds of nitrogen gathering bacteria, one of which kinds is specific to said seed, and then planting the seed.

13. The process which consists in inoculating the medium with a plurality of different kinds of nitrogen gathering bacteria to form a composite culture, and then preparing from said composite culture the cultures to be distributed.

14. The process of producing a bacteriological culture, which consists in growing a culture on a substantially solid medium and then adding a liquid to the solid medium.

15. The process of producing a bacteriological culture, which consists in first preparing a substantially solid medium, in a distributing vessel, inoculating it with nitrogen gathering bacteria, maintaining the medium under the required condition to develop the culture, then adding water to the top of the medium and finally sealing said distributing vessel.

16. A bacteriological culture comprising a medium, a plant growing in said medium and inoculated with the desired bacteria, in combination with a germ proof receptacle inclosing the plant and medium.

17. The combination, with a transparent germ proof receptacle, of a medium within said receptacle, and a plant inclosed by said receptacle and rooted in the medium, said plant being inoculated with the desired bacteria.

18. The combination, with a germ proof receptacle provided with means for maintaining a supply of sterilized air to its interior, of a medium within said receptacle, and a plant inoculated with the desired bacteria inclosed by said receptacle and rooted in the medium.

19. The combination, with a germ-proof receptacle pervious to air, of a medium within said receptacle, and a plant inoculated with the desired bacteria inclosed by said receptacle and rooted in the medium.

20. The combination, with a germ-proof transparent receptacle, of a substantially transparent medium within said receptacle and a plant inoculated with the desired bacteria inclosed and protected against contaminations by said receptacle and rooted in the medium.

21. The combination, with a glass vessel having an air-inlet and an air filter in said inlet, of a medium in said vessel, and a plant inoculated with the desired bacteria inclosed by the vessel and rooted in the medium.

22. The combination, with a vessel, having an air inlet and a lateral opening, a closure for said opening and an air filter in the air inlet, a medium in said vessel and accessible through the lateral opening and a plant inoculated with the desired bacteria, inclosed by the vessel and rooted in the medium.

23. A bacteriological culture comprising a plant inoculated with the desired bacteria, in combination with a germ-proof receptacle surrounding said plant and provided with means for permitting access to the roots of said plant.

24. A bacteriological culture comprising a medium, a plant growing in said medium and inoculated with the desired bacteria, in combination with a germ-proof receptacle inclosing the plant and medium and provided with means for permitting access to the roots of said plant.

25. A distributing package of nitrogen gathering bacteria containing a plurality of kinds of such bacteria.

26. A distributing package of nitrogen gathering bacteria comprising a composite culture of several kinds of virulent nitrogen gathering bacteria.

27. A distributing package comprising a sealed receptacle containing a substantially solid and also a liquid medium and nitrogen gathering bacteria in said media.

28. A distributing package comprising a receptacle, means for restricting the access of air to said receptacle, a substantially solid medium in said receptacle, a liquid upon said solid medium and a colony of nitrogen gathering bacteria in said medium.

29. A distributing package comprising a receptacle, means for restricting the access of air to said receptacle, a substantially solid medium in said receptacle, a liquid upon said medium, and a composite colony of different kinds of nitrogen gathering bacteria in said medium.

30. The combination, with a germ-proof receptacle provided with means for maintaining a supply of sterilized air to its interior, of a nitrogen-free medium within said receptacle and a plant inoculated with nitrogen-gathering bacteria inclosed by said receptacle and rooted in the medium.

31. A bacteriological culture comprising a nitrogen-free medium, a plant growing in said medium and inoculated with nitrogen gathering bacteria, in combination with a germ-proof receptacle inclosing the plant and medium, said receptacle being provided with means for maintaining a supply of sterilized air to its interior and with means for permitting access to the roots of said plant.

32. The process of developing a bacteriological culture, which consists in growing in a non-nitrogenous medium, a plant inoculated with nitrogen-gathering bacteria within a germ-proof inclosure, while maintaining a restricted supply of sterilized air to the interior of said inclosure, removing a nodule from said plant and inoculating a medium with said nodule.

33. The process of producing a bacteriological culture, which consists in first preparing a substantially solid medium, in a distributing vessel, inoculating it with nitrogen gathering bacteria, maintaining the medium under the required condition to develop the culture, then adding liquid to the top of the medium and finally sealing said distributing vessel.

34. A distributing package comprising a receptacle, a medium within said receptacle and a plurality of kinds of bacteria in said medium, one of said kinds of bacteria being a nitrogen-gathering bacteria specific to the particular plant on which the culture is to be used.

In testimony whereof I hereunto affix my signature in the presence of two witnesses.

GEORGE HERBERT EARP-THOMAS.

Witnesses:
M. C. MASSIE,
E. O. HILDEBRAND.

UNITED STATES PATENT OFFICE.

GEORGE H. EARP-THOMAS, OF BLOOMFIELD, NEW JERSEY.

MEANS FOR DISTRIBUTING SOIL BACTERIA.

1,099,121. Specification of Letters Patent. Patented June 2, 1914.

No Drawing. Application filed June 29, 1908. Serial No. 441,018.

To all whom it may concern:

Be it known that I, GEORGE H. EARP-THOMAS, a British subject, residing at Bloomfield, county of Essex, and State of New Jersey, have invented certain new and useful Improvements in Means for Distributing Soil Bacteria, fully described in the following specification.

This invention relates to the distribution of beneficial soil bacteria.

The desirability and practical necessity of having soils for growing all kinds of plants and crops supplied with the various species and varieties of beneficial soil bacteria is very generally recognized. Efforts to supply such bacteria to soils which are naturally deficient in them have been directed mainly to supplying the particular species of nitrogen fixing, or nitrifying, bacteria which enter the roots of leguminous plants usually forming nodules or swellings on the roots containing colonies of the bacteria, and which, like other species of nitrifying bacteria which exist independently of growing plants, fix atmospheric nitrogen in a form assimilable by plants. Two methods of supplying these nodule-forming nitrifying bacteria to soils which are naturally deficient in them have been heretofore followed; one being by distributing on the land soil from fields containing the desired bacteria, and the other by inoculating the soil or the seeds before planting with pure laboratory prepared cultures of the desired bacteria. The first of these methods, that is, the method of soil transfer, is objectionable because of the danger of spreading weeds, destructive crop diseases and harmful bacteria.

The object of the present invention is to provide an improved method and means for distributing nodule-forming nitrifying bacteria and other kinds of beneficial soil bacteria whereby any advantages belonging to the soil transfer method of inoculation, above referred to, are retained, and the disadvantages and objections to such method of inoculation entirely avoided and overcome. To this end, I propose to distribute for inoculation purposes, soil which has been freed from weed seeds and all harmful germs and bacteria, and which is inoculated with artificially or laboratory prepared pure cultures of the desired beneficial bacteria.

My method of preparing such inoculated soil is briefly as follows:—I take a quantity of soil which is favorable to the growth of the bacteria and treat the same to kill all weed seeds, disease germs and all organisms which it may contain. For this purpose, the soil is preferably sterilized by steam or dry heat, preferably the latter. A practical method of sterilizing the soil is to pass it in an even layer slowly over a sufficiently heated iron sheet, the soil being stirred and turned as it is passed over the heated surface. It may also be sterilized by the use of any suitable form of apparatus, such as is used for roasting ores or minerals; as, for example, a revolving cylinder heated to the desired degree provided with a spiral guide or flange on its interior surface by which the soil will be advanced gradually through the cylinder and at the same time agitated and stirred so as to insure the proper heating of all parts of the same. The soil thus sterilized and freed of its weed seeds, all weed seeds which it contains having been killed by the heat, is then inoculated with the desired beneficial bacteria. Artificially prepared pure cultures are used for this purpose, and the inoculation is preferably performed by mixing with the sterilized soil a more or less diluted solution of the culture, the amount of bacteria used depending upon the amount of the inoculated soil which is to be used for inoculating a given area of land.

If soil of the proper character and composition is used, the bacteria will thrive in the same, increasing in numbers and remaining in an active and virile condition for a considerable length of time, and the inoculated soil may be shipped to all parts of the world with the certainty that it will reach its destination in good condition.

The inoculated soil may be sown on the land like seed in the condition it is received by the user, but a preferred method of using it is to mix the amount of soil furnished for an acre of ground with, say, a cartload of soil from the field to be inoculated and then spread such soil evenly over the field, harrowing it in as soon as possible.

The soil to be sterilized and inoculated should be of a character favorable to the growth of the desired bacteria, containing the necessary elements for sustaining the bacterial life, but almost any ordinary garden soil may be used. It is preferable, however, to use a non-nitrogenous soil, or one which is free, or substantially free from nitrogen. This for the same purpose that it is desirable in growing laboratory cultures

to use a non-nitrogenous medium, that is, to cause and accustom the bacteria to take the nitrogen which they require from the air rather than to feed on nitrogen contained in the soil. If the soil is lacking in carbonates or carbo-hydrates or other elements or substances which the bacteria require, they should be supplied. As the soil is to be quite heavily inoculated with bacteria it should contain a comparatively large supply of carbonaceous matter, and if the carbonaceous matter is not in the soil in sufficient quantities this is corrected preferably by the addition of nitrogen-poor humus or clay-loam, or better, both clay-loam and humus; or the elements lacking may be supplied in chemical form. Ordinary garden soil with the addition of say 10 to 20 per cent. of humus and clay-loam will usually be found to contain all necessary substances for the growth of the bacteria. Of course much larger relative quantities of these substances may be used if desired, or clay-loam alone or a mixture of clay-loam and nitrogen-poor humus would answer the purpose well.

When humus and clay-loam, or either of them, is added to the soil, they may be added before sterilization, and the combined soil then treated to sterilize it and kill the weed seeds; or the constituents may be separately treated. A good method is to sterilize clay-loam which is to be added to the soil separately from the main body of the soil, and then to inoculate it and mix the moistened and inoculated clay-loam with the main portion of the sterilized soil. When the sterilizing is done by dry heat, it is sometimes desirable to add carbo-hydrates in the form of sugar, maltose or its equivalent to the soil after it is sterilized. Unless carbonaceous matter is to be added after sterilization, the temperature during sterilization must not be high enough to destroy the carbonaceous matter in the original soil.

For most forms of the nodule-forming bacteria, the soil should be neutral or slightly alkaline, and if the soil to be used should be acid, this should be corrected by the addition of a suitable quantity of lime, preferably in the form of carbonate of lime. With regard to the physical condition of the soil, it is desirable that it be of a light character to admit air readily, friable, of fine texture, and of an absorbent nature.

The soil may be inoculated with a single species or variety of beneficial bacteria, or with a plurality of species or varieties. Soil for inoculating land for growing a particular species of legume may be inoculated with only the particular kind or variety of nodule-forming bacteria corresponding to the particular legume; or the soil may be inoculated with the various kinds or varieties of nodule-forming bacteria belonging to the commonly used legumes, either by inoculating with separate cultures of each different variety of the bacteria or with a composite culture containing the various varieties of these nodule-forming bacteria with which the sterilized soil is to be inoculated. Such composite cultures for inoculating the soil may be produced as set forth in United States Letters Patent No. 865,965, granted to me September 10th, 1907. Soil inoculated with nodule-forming bacteria specific to the several legumes may be used for inoculating land for growing any of such legumes or their closely related species. In order to produce an inoculated soil for inoculating land for growing various kinds of legumes, it will not be necessary in practice to inoculate with the specific bacteria for each of the various species of legumes to be grown, but it will usually be sufficient to inoculate with bacteria specific to one or more species of each of the different groups of closely related species of legumes. For example, soil inoculated with bacteria specific to red clover would answer for inoculating land for growing alsike or white clover.

In preparing inoculated sterilized soil for inoculating land for growing legumes, I prefer to inoculate the soil not only with the nodule-forming bacteria, but also with other kinds of beneficial soil bacteria, such as the independent or non-symbiotic nitrifying bacteria, and the peptonizing and ammonifying bacteria.

The use of inoculated soil prepared in accordance with this invention is, of course, not limited to the inoculation of land for growing leguminous crops. Sterilized soil may be inoculated with other forms of bacteria such as have been already isolated or which may hereafter be isolated which are specific to various crops other than legumes; and soil inoculated with the independent forms of nitrifying bacteria and preferably also with the peptonizing and ammonifying bacteria or other forms of beneficial bacteria will be found to be of value for general use for inoculating land which is deficient in such bacteria. It is also desirable to have the inoculated sterilized soil prepared for such general use inoculated with the nodule-forming or legume bacteria.

While for most forms of beneficial bacteria the soil should be, as before stated, neutral or slightly alkaline, yet certain forms of nodule-forming bacteria specific to certain legumes thrive best in a slightly acid medium or soil, and in order to get the best growth and most marked results from these particular bacteria the soil to be inoculated should preferably be in a slightly acid condition. The bacteria specific to cow peas, for example, thrive best in a soil which is slightly acid. Soil to be inoculated with the bacteria specific to cow peas, therefore, should not be limed, but should be allowed

to remain slightly acid, or should be made so by the addition of a suitable substance such as acid sulfates or acid phosphates. Most of the legumes, however, and their corresponding bacteria thrive best on a neutral or slightly alkaline soil, as above stated. Some, moreover, do slightly better on a soil just neutral, while others are favored by a slightly alkaline condition of the soil. I prefer, therefore, in preparing inoculated soil to be used for inoculating land for growing the various species of legumes to use soil of three different qualities with respect to their acid or alkaline condition, that is, I would use a slightly alkaline soil for inoculating for legumes which thrive best in an alkaline soil; a neutral soil for legumes which thrive best in a neutral soil; and a slightly acid soil for legumes which thrive best in a slightly acid soil.

A good method of securing the best soil to use in preparing inoculated sterilized soil in accordance with this invention, is to select soil for a particular species or group of legumes from a locality where legumes of that particular species or group have grown well and have been well supplied with healthy root nodules. After being sterilized and inoculated, the soil should be protected against contamination, especially against access of molds and other harmful organisms. The degree of protection required while being stored and during shipment will depend largely on the amount of moisture in the inoculated soil. If the soil is quite dry, molds and other organisms will not readily penetrate into it and it could be shipped in bags or ordinary boxes. If the soil is too dry, however, the growth of the beneficial bacteria will be retarded, and it is desirable to have the soil moistened sufficiently so that its condition will be favorable for their growth and development. In such moistened condition, however, molds and other harmful organisms are more liable to develop on and spread through the soil, and such moistened inoculated soil should, therefore, be sealed against access of molds and other harmful organisms in suitable receptacles for shipment, and preferably should be sealed immediately after inoculation. It is desirable that inoculation should take place as soon as the soil is cooled sufficiently after being sterilized and without its having been allowed to become contaminated. If the inoculated soil is to be kept for a considerable length of time after being sealed against access of molds and other harmful organisms, or of air laden with such, provision is preferably made for allowing sterilized air to enter the receptacle containing the inoculated soil. This may readily be accomplished by providing the receptacle with an opening which is filled with properly compacted sterilized cotton.

A good way of distributing the inoculated sterilized soil is to have a small quantity of such soil which is in a moistened condition surrounded by dry sterilized soil, which dry soil may be uninoculated sterilized soil, but which preferably will also be inoculated. The soil may be packed in this way by putting a layer of the dry soil in the bottom of a box or other receptacle, placing the moist soil on the center of said layer and then filling up the box with the dry soil. The moist soil in the center of the box will thus be entirely surrounded by dry soil. Another way of securing this result is to pack dry sterilized soil in a receptacle in which it is to be shipped and then by means of a suitable spray, syringe or other suitable instrument to inject into the center of the dry soil a sufficient quantity of liquid culture to moisten and inoculate the soil at and near the center of the package. The advantage of this method of distributing inoculated soil, that is, with moist soil surrounded with dry soil, is that the moist soil in the center will be in a condition most favorable for the development and growth of the bacteria and will be protected by the dry soil against molds and other harmful organisms. When packed in this way, the inoculated soil may be safely distributed over long distances and kept for a long time when packed in ordinary wooden boxes or even in bags.

What is claimed is:—

1. As a new article of manufacture, substantially nitrogen-free soil freed of weed seeds and harmful organisms but containing available carbonaceous matter, and artificially inoculated with beneficial soil bacteria.

2. As a new article of manufacture, substantially nitrogen-free soil containing clay and available carbonaceous matter and freed from weed seeds and harmful organisms, and artificially inoculated with beneficial soil bacteria.

3. As a new article of manufacture, soil composed of a mixture of garden soil, humus and clay-loam, the quantity of the humus and clay-loam being less than the quantity of garden soil in the mixture, and said mixed soil being freed from weed seeds and harmful organisms, and inoculated with beneficial soil bacteria.

4. As a new article of manufacture, substantially nitrogen-free soil which has been sterilized by heat, containing available carbonaceous matter and inoculated with beneficial soil bacteria.

5. As a new article of manufacture, sterilized substantially nitrogen-free soil containing available carbonaceous matter and inoculated with pure cultures of beneficial soil bacteria.

6. As a new article of manufacture, sterilized substantially nitrogen-free soil containing available carbonaceous matter and inocu-

lated with pure cultures of nitrifying bacteria.

7. As a new article of manufacture, sterilized substantially nitrogen-free soil containing available carbonaceous matter and inoculated with pure cultures of nodule-forming nitrifying bacteria.

8. As a new article of manufacture, sterilized substantially nitrogen-free soil inoculated with pure cultures of a plurality of kinds of nitrifying bacteria.

9. As a new article of manufacture, sterilized substantially nitrogen-free soil inoculated with pure cultures of a plurality of kinds of nodule-forming nitrifying bacteria.

10. As a new article of manufacture, sterilized soil inoculated with pure cultures of nodule-forming nitrifying bacteria and independent or non-symbiotic nitrifying bacteria.

11. As a new article of manufacture, sterilized soil inoculated with nitrifying, peptonizing and ammonifying bacteria.

12. As a new article of manufacture, sterilized soil inoculated with nodule-forming and independent or non-symbiotic nitrifying bacteria, peptonizing bacteria and ammonifying bacteria.

13. A new article of manufacture comprising substantially nitrogen-free soil freed of weed seeds and harmful organisms and inoculated with beneficial soil bacteria, and a protective envelop comprising pulverulent material inclosing said soil and preventing access of molds and other harmful organisms thereto.

14. A new article of manufacture comprising sterilized substantially nitrogen-free soil inoculated with beneficial soil bacteria, and a protective envelop of inorganic material pervious to air inclosing said soil and preventing access of molds and other harmful organisms thereto.

15. As a new article of manufacture, a body of soil comprising soil inoculated with pure cultures of beneficial soil bacteria, a localized portion of said body having a greater moisture content than and being protected by the remainder of said body.

16. A new article of manufacture comprising moist sterilized soil inoculated with beneficial soil bacteria, a layer of dry soil enveloping said moist soil and a closed receptacle inclosing both said soils and having an air-supply opening filled with compacted sterilized cotton.

17. As a new article of manufacture, a body of moist sterilized soil inoculated with beneficial soil bacteria and surrounded by dry sterilized soil.

18. As a new article of manufacture, a body of moist sterilized soil inoculated with beneficial soil bacteria and protected by dry sterilized soil.

19. As a new article of manufacture, a body of moist sterilized soil surrounded with dry sterilized soil, both the moist and the dry soil being inoculated with beneficial soil bacteria.

20. As a new article of manufacture, a body comprising both moist and dry soil in substantially separate arrangement, said soil being freed of weed seeds and harmful organisms and inoculated with beneficial soil bacteria, said moist soil being protected by said dry soil.

21. As a new article of manufacture, a moist medium inoculated with bacteria and surrounded by a dry powdered material.

22. As a new article of manufacture, a moist medium inoculated with bacteria and protected by a dry powdered material.

In testimony whereof, I have hereunto set my hand, in the presence of two subscribing witnesses.

GEORGE H. EARP-THOMAS.

Witnesses:
HARRY S. CONNOLLY,
A. L. KENT.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."

UNITED STATES PATENT OFFICE.

WILLIAM BEECROFT BOTTOMLEY, OF LONDON, ENGLAND.

TREATMENT OF PEAT FOR MANURIAL AND OTHER PURPOSES.

1,106,275. Specification of Letters Patent. Patented Aug. 4, 1914.

No Drawing. Application filed July 15, 1913. Serial No. 779,168.

To all whom it may concern:

Be it known that I, WILLIAM BEECROFT BOTTOMLEY, a subject of the King of Great Britain, residing in London, England, and whose post-office address is King's College, in the county of London, England, have invented a certain new and useful Improved Treatment of Peat for Manurial and other Purposes, of which the following is a specification.

According to this invention peat can be converted into an excellent manure by treating it with micro-organisms capable of producing ammonia. Such micro-organisms are obtainable by known methods from ordinary soil or from other sources such as putrefying bouillon. There are several species of them, such as *Bacillus mycoides*, *Bacillus subtilis*, *Bacterium aerogens* and *Bacterium fluorescens liquefaciens*. It is not essential to use a pure culture of any particular species or of the mixed species, since other micro-organisms may be present. The effect of these micro-organisms on the peat is to convert the humic acid and humous bodies contained in it into compounds soluble in water and at the same time to disintegrate the peat so that it is readily distributed.

A product richer in nitrogen is obtained if nitrogen fixing organisms such as *Azotobacter* and *Bacillus radicicola* are present in the mass.

In addition to its usefulness as a manure the product forms a ready source of the substances commonly classed as humic acid or humous bodies, which have lately found application in industry.

There is no difficulty in obtaining a culture of micro-organisms, containing no doubt very many species, suitable for my invention. For this purpose 10–20 grams of fertile soil may be added to a culture medium comprising 1 liter of water, 20 grams of dextrin, 1 gram of dipotassium phosphate, ½ gram of magnesium sulfate, 2 grams of calcium carbonate and 10 cc. of bouillon. The scum which forms on the surface of the liquid in the course of a few days is suitable for my invention. Pure culture consisting of any of the individual species that are active for the purpose or mixed cultures may of course be prepared, but this is not necessary so far as is at present known to me.

To the peat or peat material is added water containing the organisms and the mass is allowed to undergo the change involved, for some days. When the peat has been dried, as is the case with certain prepared peat, the amount of water added should suffice to moisten the mass thoroughly. It is not, however, necessary to dry the peat, for if this is in its natural wet condition it may be merely sprinkled with the water containing the mirco-organisms.

The process is preferably hastened by adding to the mass a nitrogenous organic material, particularly a weak solution of a soluble nitrogenous organic material, such as albumin, gelatin or meat extract; a solution containing say 0.25–0.5 per cent., of any standard meat extract, for example will serve. Such a solution may constitute the liquid in which the micro-organisms may be contained as aforesaid. I have found that a very suitable nitrogenous extract consists of the waste liquor obtained from the boiling of bones. It is also desirable to add a small proportion of a carbohydrate such as sugar or starch; say about 0.1 per cent. of the dry weight of the original peat, dissolved or suspended in a little water.

The saturated peat may be left at a temperature of 24–30° C. for three weeks or thereabout and may then be dried. In this condition it may be applied directly as a manure. Or before it is dried it may be sterilized, such as by live steam, and then further treated with nitrogen-fixing organisms for increasing the amount of nitrogen in the mass, these organisms being capable of growing in the altered peat.

If soluble humous substances be required the treated mass may be leached with water and the solution used directly for any of the purposes to which humus is applied; or an acid may be added to precipitate the humic acid from the aqueous solution. The aqueous extract of the treated peat is also useful as a liquid manure.

Having thus described the nature of my said invention and the best means I know of carrying the same into practical effect, I claim:—

1. A process of treating peat which consists in adding to the moist peat aërobic micro-organisms capable of producing ammonia and allowing these micro-organisms to multiply in the peat.

2. A process of treating peat which consists in adding to the moist peat aërobic

micro-organisms capable of producing ammonia and nitrogen-fixing micro-organisms and allowing the said micro-organisms to multiply in the peat.

3. A process of treating peat which consists in adding to the peat water containing ammonia-fixing micro-organisms and drying the material after some days.

4. A process of treating peat which consists in adding to the peat water containing ammonia-fixing micro-organisms and nitrogen-fixing micro-organisms and drying the material after some days.

5. A process of treating peat which consists in adding to the peat water containing ammonia-fixing micro-organisms, then sterilizing the material and adding to it nitrogen-fixing micro-organisms.

6. A process of treating peat which consists in adding to the peat nitrogenous material adapted to be converted in part into ammonia, then adding to the moist peat ammonia-producing micro-organisms and drying the material after some days.

7. As a new product peat which has been subjected to the action of ammonia-producing micro-organisms and contains soluble humates.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

WILLIAM BEECROFT BOTTOMLEY.

Witnesses:
JOSEPH MILLARD,
GEO. J. M. FRANKLIN.

UNITED STATES PATENT OFFICE.

GEORGE H. EARP-THOMAS, OF GLEN RIDGE, NEW JERSEY.

BACTERIAL PRODUCT AND PROCESS OF PREPARING SAME.

,252,332. Specification of Letters Patent. Patented Jan. 1, 1918.

Drawing. Application filed March 30, 1917. Serial No. 158,625.

o all whom it may concern:

Be it known that I, GEORGE H. EARP-HOMAS, formerly a citizen of New Zealand, t who have declared my intention of be-ming a citizen of the United States, resid-g at Glen Ridge, in the county of Essex d State of New Jersey, have invented cer-in new and useful Improvements in Bac-rial Products and Processes of Preparing me; and I do hereby declare the following be a full, clear, and exact description of e invention, such as will enable others illed in the art to which it appertains to ke and use the same.

This invention relates to bacterial prod-ts and processes of preparing same; and particular it relates to bacterial products mprising inoculated material, most desir-ly in the form of grains or granules, ated or covered with a protective substance such manner as to afford protection to id inoculated material from injury or con-mination to which it may be exposed by ason of its environment. The invention especially useful when it is desirable to sociate a bacterial culture with material such character or chemical reaction as uld exercise an injurious or unfavorable ect on the unprotected culture.

The difficulty of preventing infection or ntamination of bacterial cultures by for-n micro-organisms, especially when the tures are to be used or kept outside of a oratory or transported from place to ce, is well known. Many types of bac-ia such as the nitrogen-gathering or ni-gen-fixing bacteria (*Pseudomonas radi-ola*) infesting the roots of legumes, for mple, are aerobic, and hence any means pted for exclusion of foreign and harm-micro-organisms from culture of such teria must nevertheless permit access of to the cultures. For the convenient com-rcial storage and transport of such cul-es *en masse*, a container of the character closed in my Patent 1,137,388 of April 1915, has proved eminently satisfactory practice; but, as will hereinafter appear, s sometimes desirable to transport or to ploy such a culture in the form of rela-ly small discrete bodies, pieces, or gran-, and in such cases the present invention be practised to great advantage.

n accordance with the present invention, ody consisting of or comprising a bac-al culture is protected from infection and contamination by providing said body with an adherent protective coating of a suitable substance which in itself is substantially indifferent toward the culture, or which at any rate does not deleteriously affect the same, said substance being of such nature as to shield the culture from contact with substances to which it would otherwise be exposed by reason of its environment. More particularly, the invention is directed to protecting in this way small bodies, particles, or granules, of suitable material which has been inoculated with beneficial micro-organisms, such as beneficial soil bacteria. As typical of such beneficial soil bacteria may be mentioned ammonifying bacteria, which convert the insoluble nitrogen of organic matter into ammonia; nitrifying bacteria, (*e. g. Nitrosomonas*) which convert ammonia into nitrous acid; nitrate bacteria (nitrobacter), which carry the oxidation to the nitrate stage; and nitrogen-fixing bacteria, both symbiotic (*e. g. Pseudomonas radicicola*) and non-symbiotic (azotobacter); as well as other bacteria which I have found to grow vigorously in nitrogen-free media and which are useful in soil improvement, but which have not all been individually isolated and identified. An especially desirable result attainable by means of my invention is that granular inoculated material, provided with a protective coating of the general character described, can be mixed with other fertilizer materials, especially with chemical fertilizers having an acid or basic reaction of such character or intensity as would interfere with or inhibit the growth and development of unprotected beneficial micro-organisms. Cultures coated in accordance with the invention retain their activity and virulence unimpaired under conditions which would destroy or seriously affect cultures not thus protected.

While particular advantages are realized in applying the principles of the invention to the manufacture of mixed fertilizers in the manner mentioned, it is to be understood that the invention is capable of other applications, as will appear more fully hereinafter, and that it is therefore not limited to the fertilizer art. In order to explain the principles of the invention more fully by way of a concrete example, however, the application thereof to the preparation of a mixed fertilizer will be described in detail.

Cultures of bacteria suitable for use in

practising the present invention may be prepared in any suitable way, but the methods described in my prior Patents 816,850 and 865,965 are especially desirable. Pure cultures or mixed cultures of bacteria or other micro-organisms, having thus been prepared in any suitable manner, and most advantageously in a highly virulent condition, are used for the inoculation of specially prepared fine granular material which has been thoroughly mixed and dried out to a desirable point, which point is, however, considerably short of complete desiccation. This granular material is desirably a substance such as peat, humus, or muck, which may be generically termed humus material or humus-like material, although any other suitable material for the growth of bacteria may be employed, such as comminuted wood fiber for example. For several reasons, humus material is especially valuable for the purposes in view. It is nitrogen-free in the sense that it contains substantially no nitrogen in a form directly available to nitrobacteria; and this is important in maintaining the bacteria virulent. On the other hand, it contains nitrogen in insoluble form which is convertible into ammonia, and therefore eventually made available, by ammonifying bacteria, especially in the presence of suitable basic or antacid substances. Furthermore, humus material is naturally very high in hydroscopic moisture content which it retains tenaciously, samples of peat which have been thoroughly air-dried very commonly containing from 20 to 40 per cent. of hydroscopic moisture. Since a moist medium is essential to continued virulence of bacteria, this characteristic of humus material is of very great importance for present purposes.

If not in itself adapted to serve as food for bacteria, the granular carrier material can be made suitable for the growth of the bacteria by impregnating or otherwise supplying it with soluble nutrients, such as malt sugar, sucrose, etc., and adding certain inorganic agents such as potassium phosphate, magnesium sulfate, wood ashes, all compounded to suit the particular type of micro-organisms to be grown. The granulated carrier is inoculated before or after addition of nutrients with the prepared pure or mixed cultures by methods well known in the art, and the material is then treated with a suitable protective material in such manner as to provide the bacteria with the requisite protection. As protective agents, a large number of materials are satisfactory and readily available. Speaking generally, it is desirable that the coating agent employed be such as will give a very thin tough and closely adherent coating. Agar-agar, and the seaweed jellies generally, give this type of coating and are therefore especially well adapted for the purpose. Among other coating and binding agents useful under certain circumstances in carrying out the invention may be mentioned colloidal material generally, so-called soluble celluloses, gums, resins, waxes, carbohydrates incuding starches, dextrin, glucose, etc., gelatin, glue, clays and the like. These coating agents may be used individually or in various combinations. Thus, for example, a compound coating of gums or glues and a syrup has certain advantages; and a mixture of waxes and syrups works well.

These various coating agents give coatings whose permeability to air, while differing considerably is sufficient for the purposes of the invention. Aerobic bacteria, when grown in a confined space, soon reduce the pressure therein below atmospheric, and eventually a rather high degree of vacuum is attained. For this reason the inclosed bacteria can draw their required air supply through a coating which is only very slightly pervious to air.

The actual operations involved in preparing coated cultures according to the invention may vary considerably, but a typical and desirable form of procedure as carried out in practice for producing coated nitrobacteria cultures is substantially as follows: A good quality of peat or other humus material is dried and sifted to secure a fine granular carrier material of uniform character. As before pointed out, peat or humus material broadly is especially suited for the purposes of the invention because it contains nitrogen which though ordinarily unavailable, can readily be made available as food for beneficial soil bacteria, especially nitro-bacteria. For this reason and also because, generally speaking, a mildly alkaline reaction favors the growth of the bacteria, the reaction of the peat, if acid, may be corrected by adding thereto the proper amount of lime or other alkaline or antacid agent. The addition of wood ashes is particularly to be recommended. The peat may be rendered still more favorable to bacterial growth by addition of other bacterial food and stimulants as above set forth.

After this preliminary treatment, or simultaneously therewith, the humus material is inoculated; and in this typical example it is inoculated with a mixed culture of nitro-bacteria, comprising ammonifying bacteria, nitrifying bacteria, and nitrogen-fixing bacteria (*e. g. Pseudomonas radicicola* and azotobacter), this combination of bacteria having been found especially advantageous in practice. Other beneficial nitrogen-fixing bacteria above referred to as not specifically identified, but which are obtainable from various kinds of soil and which I have found to exercise a distinctly favorable effect on the development of other nitro-bacteria

when associated therewith, may be included in the mixed culture to advantage, but this is not essential. One way of conveniently accomplishing the inoculation is by impregnating the prepared peat with a liquid nutrient medium containing the mixed culture grown, for example, by the methods of my prior patents aforesaid. The inoculated peat is next dried cautiously in a suitable pan until the particles or granules of peat will freely separate; but complete drying or desiccation of the material is to be avoided, for reasons before explained. In using peat, however, there is not much danger of excessive drying because of the tenacity with which peat holds moisture. The pan is then revolved, and the operation of coating the granules begins. In the present example, agar-agar is employed as the coating agent. Liquid agar-agar jelly is prepared in the usual manner by heating agar-agar with water until a readily fluent homogeneous mixture is obtained. After cooling to a temperature at which the bacteria will not be injured, say about blood heat (37° C.), the liquid jelly is gradually poured into the revolving pan until the humus granules have taken up about all they will. The mass is then partly dried in the revolving pan to remove excess moisture, yielding granules both impregnated and coated with agar-agar. Most desirably the granules are given two more coatings in the same way already described for the first coat. A little drying powder, such as powdered talcum or chalk, added to the mass in the pan, and application of a warm air blast serve to hasten the drying of the mass. Talcum and chalk are also useful to prevent the coated granules from sticking together and to cover the final coating thoroughly. It is desirable also to add a little powdered boric acid or borax to the material during the drying. This does not hurt the inclosed bacteria and is effective in keeping the material from molding while drying out and before it is placed in cans for shipment. Furthermore boric acid and borax also act as good lubricants in the pan, separating the granules as they are being dried and preventing their sticking to the pan and to each other.

The coating obtained by the use of agar-agar jelly in the manner described is particularly desirable in character. In drying, the agar-agar membrane shrinks down upon the particle or granule of material which it covers and clings to it tenaciously, conforming accurately to the contour of the protected surface. Moreover the coating is strong and tough, resistant, and neutral. When, as in the case of a fertilizer, the coated particle is applied to soil and exposed to a moist environment, the agar-agar coating does not immediately disintegrate, but first softens and swells while still affording protection to the inclosed culture which, however, is now free to propagate through the soft jelly wall and begin its beneficial action on the soil.

Where desirable a sugar solution or glucose, either of which serves admirably as a coating agent, may replace, or may be used in conjunction with, agar-agar in the procedure above described. They have several characteristics which render them valuable for certain purposes as coating agents, among which may be noted their solubility and their nutrient properties. By reason of the latter they serve not only as protective coating agents but also as bacterial foods; while their solubility insures that the contained bacteria cultures shall be very promptly freed for action when the coated material is placed in a moist environment.

The granular inoculated material, when coated as above described, may be packaged and distributed in this form. But it is especially useful for mixing with other fertilizing materials in the proper proportions to give a suitable mixed or complete fertilizer. Such additional fertilizing materials include, for example, lime, gypsum, dolomite, acid phosphate, muriate and sulfate of potash, magnesia, basic slag, phosphate rock, tankage, humus, manure, etc. In the mixed fertilizer prepared according to the present invention, the bateria are protected from direct contact with acid or alkali matter and their growth and development are therefore unimpeded. The dust or other portions of the acid or alkali chemicals or other injurious matter contained in the added fertilizer material will not penetrate and come into contact with the delicate structure of the micro-organisms inclosed in the coated granules or particles.

It is to be noted also that, in addition to the fact that the micro-organisms in the coated granules are shielded from undesirable contact with the admixed fertilizer materials, said admixed materials, if they happen to be distinctly acid or basic in reaction, act as a further protection to prevent access of undesirable foreign micro-organisms to the beneficial micro-organisms. The inoculated material is therefore protected by a material destructive to micro-organisms; but is nevertheless shielded from direct contact therewith.

As before stated, the invention is not limited to the mixing and distribution of beneficial bacteria or micro-organisms with chemical fertilizers. The method of coating bodies of inoculated material in the manner described constitutes broadly a desirable way of distributing bacteria and protecting them against contamination during transit, whether said inoculated material be accompanied or not by additional material of any kind. Coated bodies, pieces, gran-

ules, or particles of material inoculated with beneficial soil bacteria are useful alone for direct application to the soil. The coating not only acts as a protection during distribution, but it also acts as a protection in the soil against harmful micro-organisms. The beneficial bacteria are thus supplied with a nidus for growth from which they can propagate and produce their chemical products which are valuable in increasing the available nitrogen content of the soil and in producing acids which make available the potential plant foods of the soil itself.

The principles of this invention can also be extended to the distribution of beneficial micro-organisms for consumption by man and animals by preparing specially granulated material, inoculating it with suitable syrup solutions containing beneficial bacteria, and then coating the inoculated granules with a soluble protective material. The cultures are subsequently liberated during the process of digestion, the period required for liberation being dependent upon the solubility of the particular substance employed to coat the granular material.

While a practical way of carrying out the invention has been described above for the sake of a concrete example, it is to be understood that various changes and modifications may be introduced while still realizing the advantages of the invention to a greater or less extent. For instance, instead of proceeding as in the specific example given it is feasible to mix the inoculated carrier substance, such as peat or the like, with a protective binder such as agar-agar, syrups, etc., then to force the mixture through a perforated plate to granulate or comminute it, and finally to dry the comminuted material to a desirable extent, either with or without further treatment with protective material. The product contains active bacteria carried in a sufficiently moist medium and shielded by adherent protective material. This and all other forms of the method and product coming properly within the broad scope of the invention are contemplated herein.

What I claim is:

1. As a new article of manufacture, material inoculated with micro-organisms and protected by an adherent substance.

2. As a new article of manufacture, material inoculated with micro-organisms and provided with an adherent protective covering of colloidal material.

3. As a new article of manufacture, material inoculated with micro-organisms and coated with material of a gummy nature.

4. As a new article of manufacture, material inoculated with micro-organisms and coated with a soluble protective material.

5. As a new article of manufacture, inoculated material in granular form, protected by an adherent substance.

6. As a new article of manufacture, inoculated material in the form of discrete particles or granules, each provided with an adherent protective coating.

7. As a new article of manufacture, inoculated material in the form of discrete particles or granules, each provided with an adherent coating superficially treated to prevent the granules from sticking together.

8. As a new article of manufacture, material inoculated with beneficial micro-organisms and coated with agar-agar.

9. As a new article of manufacture, granular material inoculated with beneficial bacteria and protected by a substance of gum-like character.

10. As a new article of manufacture a culture of nitro-bacteria in active condition provided with an adherent coating of protective material.

11. As a new article of manufacture a relatively moist medium inoculated with nitro-bacteria in virulent condition and provided with an adherent coating of protective material.

12. A fertilizer composition comprising pieces or particles of inoculated material provided with an adherent protective coating.

13. A fertilizer composition comprising pieces or particles of material inoculated with bacteria beneficial to soil and coated with a protective substance, and additional fertilizer material mixed therewith.

14. A fertilizer composition comprising granular material inoculated with suitable nitro-bacteria and provided with a protective coating, and additional fertilizer material mixed therewith.

15. A fertilizer composition comprising granular material of relatively high moisture content inoculated with ammonifying, nitrifying, and nitrogen-fixing bacteria and provided with a protective coating, and chemical fertilizer material mixed therewith.

16. A fertilizer comprising the combination, with particles or granules of humus-like material, inoculated with ammonifying, nitrifying and nitrogen-fixing bacteria and coated with a protective substance, of additional fertilizer material mixed therewith.

17. As a new manufactured product, the combination, with suitable material inoculated with useful bacteria and protected by an adherent substance, of material antagonistic to bacterial growth surrounding such protected material.

18. As a new manufactured product, the combination, with particles of a suitable material, such as peat or humus, inoculated with beneficial soil bacteria and protected by an adherent substance relatively inert

aracter, of a fertilizer material admixed th such protected particles and of a charer unfavorable to bacterial growth.

19. As a new manufactured product, the nbination, with particles of a suitable maial, such as humus, inoculated with beneal soil bacteria and coated with a protece substance relatively inert in character, a mineral fertilizer of acid or basic reion admixed with such coated particles.

20. The process of preparing useful bacial products which comprises inoculat suitable material with micro-organisms, d treating the inoculated material with an hesive protective substance.

21. The process of preparing useful bacial products which comprises inoculating table material with micro-organisms, and ting the inoculated material with a nmy or colloidal substance.

22. The process of preparing useful bacial products which comprises inoculating nular material, mixing a liquid coating stance therewith, and drying the mixture ile substantially maintaining its granular m.

23. The process of preparing useful bacial products which comprises inoculat granular material, mixing a liquid coat substance therewith, drying the mixture l adding a non-adhesive substance during drying to maintain the granular charer of the product.

24. The process of preparing useful bacial products which comprises prelimiily treating humus material to render it non-acid in reaction, adding a nutrient thereto, inoculating the composition with a mixed culture of several varieties of nitrobacteria, mixing a liquid protective material with the inoculated mass, and drying under proper conditions to secure a granular product.

25. The process of preparing useful bacterial products which comprises preliminarily treating humus material to render it still more favorable to bacterial growth, inoculating it with a substantially liquid culture of ammonifying, nitrifying and nitrogen-fixing bacteria, drying until the inoculated material granulates, and then coating the granules with an adherent protective material.

26. The process of preparing useful bacterial products which comprises preliminarily treating humus material to render it still more favorable to bacterial growth, inoculating it with a substantially liquid culture of ammonifying, nitrifying and nitrogen-fixing bacteria, drying until the inoculated material granulates, and then coating the granules with agar-agar.

27. The process of preparing a mixed fertilizer which comprises inoculating a suitable material with beneficial soil bacteria, coating the inoculated material with a protective substance, and mixing the resultant product with other material having fertilizing value.

In testimony whereof I hereunto affix my signature.

GEORGE H. EARP-THOMAS.

UNITED STATES PATENT OFFICE.

GEORGE H. EARP-THOMAS, OF GLEN RIDGE, NEW JERSEY

FERTILIZER AND PROCESS OF MAKING SAME.

1,309,723. Specification of Letters Patent. Patented July 15, 1919.

No Drawing. Application filed April 10, 1917. Serial No. 160,960.

To all whom it may concern:

Be it known that I, GEORGE H. EARP-THOMAS, formerly a citizen of New Zealand, but who have declared my intention of becoming a citizen of the United States, residing at Glen Ridge, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Fertilizers and Processes of Making Same; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to fertilizers and processes of making same; and it comprises growing suitable nitro-bacteria in the presence of material, especially a phosphatic or potassiferous mineral, containing plant food in unavailable form, whereby such material is modified and rendered suitable for fertilizer purposes.

In particular the invention is concerned with the treatment of raw phosphate rock, *e. g.*, apatite, phosphorite, "land rock", etc., with humus, peat, muck, or the like, carrying ammonifying, nitrifying and nitrogen-fixing bacteria, the conditions of treatment being such that the insoluble tricalcium phosphate of the raw mineral becomes wholly or in part converted into a form or forms, such as mono-, di-, or tetra-calcium phosphate, in which the phosphoric acid is relatively soluble and available as plant food. Aside from this decomposing action on the mineral, the nitro-bacteria present in the resultant material also exert a beneficial action on the soil upon which the material is used as a fertilizer, by increasing its available nitrogen content. The material may be made a complete fertilizer by adding potash salts thereto; or a mixture of phosphate rock and a potassiferous mineral, such as feldspar, may be acted upon in the first instance by decomposing bacteria, that is, bacteria capable of effecting decomposition, resulting in the production of a fertilizer containing both potash and phosphoric acid in available form, as well as beneficial bacteria.

It has been the practice heretofore to treat raw phosphate rock with sulfuric acid to render its contained phosphoric acid available as plant food. But this method involves considerable expense and technical difficulty. It is still more difficult and expensive, according to methods heretofore proposed, to render available the potash contained in natural minerals such as feldspar, alunite, leucite, etc. In contrast to such methods, the present invention affords a ready and comparatively inexpensive way of solubleizing or rendering available the fertilizer values locked up in many minerals, especially phosphatic and potassiferous minerals; and furthermore the resultant product is more effective and valuable as a fertilizer than the products obtained by said other methods.

In order to explain clearly the principles of the invention, the application thereof to the treatment of raw phosphate rock will be described in detail. As above pointed out, however, the invention is broad in scope and accordingly the specific explanation hereinafter given is to be understood as illustrative and not limiting.

The first requirement is a suitable material, at least partly organic in character, to serve as a carrier and nutrient medium for the bacteria to be used. Humus-like or humus-containing material, of which humus, muck, peat, etc., are typical, is most desirable for this purpose, and peat itself is peculiarly adapted, by reason of its composition and other characteristics, to give good results. In preparing it for use, the peat is thoroughly drained in the field and is then worked frequently until it is well aerated and in good productive condition. It is then collected, sun dried or artificially dried, and generally sterilized by streaming steam or dry heat to destroy its microscopical life as well as any weed seeds that may be present. By this treatment, the peat may be freed from molds and harmful bacteria. A careful grinding or sifting puts the dried peat in good condition for further treatment. If the peat available is acid in reaction, this should be corrected by the addition of alkaline or antacid substances such as well slaked lime, calcium carbonate, carbonates of pot-

ash, soda, magnesia, etc., for the reason that a slightly alkaline medium is most favorable to growth of the bacteria employed in the present process. It is also desirable to increase the nutrient properties of the peat or humus and its efficiency as a medium for bacterial growth by adding small percentages of sugar, glucose, ground sprouted barley, ground malt, extract of malt, waste products from sugar manufacture, water, or the like; and finely ground sea weed, kelp, wood ashes, or potash-bearing rock. A small amount of sulfur in the mixture also has an excellent effect; and adding an ammonium salt, such as ammonium sulfate, is particularly effective in initiating and promoting bacterial growth. Any or all of these ingredients, and others of similar character, may be used to promote bacterial activity; the choice of ingredients and the proportions thereof depending upon the character and composition of the particular lot of peat undergoing preparation, and upon the particular species of bacteria to be used.

In practice it is generally most convenient to thoroughly mix together the prepared peat or humus and the finely divided rock phosphate. To insure the best results, it is best to use phosphate rock which has been ground to fine mesh. Where the peat used is of good quality and comparatively high in organic nutrient matter, a complete mixture ready for inoculation may be made up in substantially the following proportions, per ton.

Finely ground raw phosphate rock	900	pounds
Moist sifted peat or humus	925	"
Calcium carbonate	100	"
Wood ashes	65	"
Ammonium sulfate	5	"
Extract of malt	5	"

Sufficient tap-water to allow for evaporation.

This mixture is inoculated with a pure culture, or with mixed cultures of suitable nitro-bacteria and peptonizing bacteria. The term nitro-bacteria is here used to designate generically such bacteria as ammonifying bacteria, nitrifying bacteria (nitrosomonas), nitrate bacteria, (nitrobacter), nitrogen-fixing bacteria, both symbiotic (pseudomonas radicicola) such as infest the roots of legumes, and non-symbiotic (azotobacter); also certain nitrogen-fixing bacteria such as clostridium pasteurianum, for example, and others which I have not identified by species, but whose presence, though not essential, seems to have a desirable stimulating effect upon the growth of the other bacteria above mentioned. Virulent cultures of the various bacteria required, either pure or mixed, can be prepared to best advantage by methods set forth, for example, in my prior Patents Nos. 816,856 and 865,965; and inoculation of the prepared peat and phosphate rock mixture therewith can be effected by suitably diluting the agar-agar or other original culture with water, and sprinkling it upon the mixture which is thoroughly stirred meanwhile.

In practice it is found most desirable to use mixed cultures of ammonifying, nitrifying and nitrogen-fixing (symbiotic and non-symbiotic) bacteria for inoculating the peat, as most efficient conversion of the raw phosphate rock is thereby attained, and at the same time the resultant fertilizer material is also especially desirable as a means for distributing legume bacteria and for application to the soil.

It will be seen that in the foregoing specific example the moistened humus material constitutes roughly about one-half of the mixture; and while the proportions may be varied considerably in practice, it is usually desirable to have the humus material or its equivalent, together with the other ingredients added to promote bacterial growth, constitute a large or even a major proportion of the mixture, so that the converting bacteria may flourish and multiply rapidly.

Instead of mixing the peat and phosphate rock before inoculating, either the peat or the rock may be first inoculated, and mixture effected afterward. It is often desirable to sterilize the phosphate rock also before using it.

It is of course immaterial for the purposes of this invention what may be the true explanation of the decomposing or solubleizing action of the bacteria on the raw phosphate rock in the foregoing example; but a probable explanation seems to be that the ammonifying bacteria decompose the organic nutrient material of and in the humus, forming ammonia and organic acids; and that the nitrifying or nitrite bacteria convert the ammonia into nitrous acid, which reacts with the tri-calcium phosphate of the phosphate rock to give soluble di-calcium or mono-calcium phosphate, or both, and calcium nitrite. If nitrate bacteria (nitrobacter) are present, the nitrite eventually is oxidized to nitrate.

Whatever may be the correct explanation, the fact remains that raw rock phosphate, when mixed with inoculated humus as herein described, undergoes a conversion which renders its phosphoric acid available. The rate of conversion depends upon various factors such as temperature, intensity of inoculation, etc., and is accordingly controllable within certain limits. It is practicable to ship the inoculated material to the dealer or farmer at once; but in order to insure a virulent growth and large numerical increase of the active microorganisms,

ith resultant high efficiency in the decomosing or converting action on the phoshate rock, it is much better to store the aterial for some time at a temperature avorable to bacterial development. As a ule, storage at approximately 25° C. for period of from 35 to 50 days gives an bundant growth of highly actice bacteria nd a sufficiently high degree of conversion f insoluble phosphate into available form o render the product ready for market.

As aids to nitro-bacteria in the conver-ion process of the present invention may be mployed other acid-producing bacteria, ctic acid and butyric acid bacteria, for exmple, being very efficient when used in onjunction with nitro-bacteria in the manr above set forth.

The fertilizer material obtained as decribed may be modified to give a complete rtilizer by mixing with it compounds of otash and nitrogen, for example, in suitble proportions for any desired formula.

In treating potash-bearing minerals, such s feldspar, gneissalunite and leucite, or ther minerals containing plant food in unvailable form, in accordance with the inention, the procedure is similar in general o that herein recommended for the treatent of raw phosphate rock.

What I claim is:

1. The process of preparing a fertilizer hich comprises subjecting finely divided aw phosphate rock to the decomposing acion of nitro-bacteria in the presence of an dmixed humus-like material which has een treated to improve it as a culture meium.

2. The process of preparing a fertilizer hich comprises treating peat or humus to emove acidity, adding thereto a promoter f bacterial activity, admixing finely diided phosphatic rock, and inoculating the ixture with nitro-bacteria in virulent conition to effect decomposition of the phoshate rock.

3. The process of preparing a fertilizer hich comprises inoculating humus with itro-bacteria and other acid-producing bacria, and subjecting raw phosphate rock to he decomposing action of the inoculated umus.

4. The process of preparing a fertilizer hich comprises subjecting a mineral conining plant food in unavailable form to he decomposing action of nitro-bacteria in he presence of an admixed humus-like maerial which has been treated to improve it s a culture medium.

5. The process of preparing a fertilizer hich comprises preliminarily treating huus-like material to improve it as a medium r bacteria, intimately mixing the treated aterial with a finely divided mineral containing plant food in unavailable form, and inoculating the mixture with ammonifying, nitrifying and nitrogen-fixing bacteria to render the plant food in said mineral available.

6. The process of preparing a fertilizer which comprises intimately commingling humus-like material, and finely divided phosphatic and potassiferous minerals, with ammonifying, nitrifying, and nitrogen-fixing bacteria, to effect a chemical change in said minerals.

7. The process of preparing a fertilizer which comprises growing nitro-bacteria and lactic acid bacteria in a mixture of humus and a mineral containing plant food.

8. The process of preparing a fertilizer which comprises subjecting an intimate mixture of finely divided phosphatic and potassiferous minerals with humus-like material to the decomposing action of nitro-bacteria.

9. The process of treating mineral matter to render available plant food contained therein in unavailable form which comprises subjecting such mineral matter to the decomposing action of humus-like material inoculated with nitro-bacteria.

10. The process of treating mineral matter to render available plant food contained therein in unavailable form which comprises subjecting such mineral matter to the decomposing action of humus-like material inoculated with nitro-bacteria, said humus-like material containing an added substance serving to promote bacterial activity.

11. The process of preparing a fertilizer containing available phosphoric acid which comprises mixing peat or humus, finely divided phosphate rock, and an antacid substance, and inoculating the mixture with bacteria capable of exercising a decomposing action on said phosphate rock.

12. The process of preparing a fertilizer containing available phosphoric acid which comprises mixing peat or humus, finely divided phosphate rock, a suitable antacid substance, and nutrient material, and inoculating the mixture with bacteria capable of exercising a decomposing action on said phosphate rock.

13. The process of preparing a fertilizer containing available phosphoric acid which comprises inoculating phosphate rock with selected nitro-bacteria capable of exercising a decomposing action thereon, and maintaining the inoculated rock under incubating conditions until a substantial proportion of the phosphoric acid of said rock has been rendered available for plant food.

14. The process of preparing a fertilizer which comprises inoculating phosphate rock with nitrifying bacteria and maintaining the inoculated rock at a favorable incubating

temperature until a substantial proportion of the phosphoric acid of said rock has been rendered available for plant food.

15. The process of preparing a fertilizer which comprises preparing a mixture of finely divided phosphate rock, a nutrient medium, and ammonifying, nitrifying, and nitrogen-fixing bacteria, and maintaining the inoculated mixture under incubating conditions until a substantial proportion of the phosphoric acid of said rock has been rendered available for plant food.

16. The process of preparing a fertilizer which comprises preparing a mixture consisting mainly of finely divided phosphate rock and humus-like material, said mixture also containing a small percentage of an ammonium salt and being inoculated with nitrifying bacteria, and maintaining the mixture under suitable incubating conditions to effect conversion of said phosphate rock.

17. The process of preparing a fertilizer which comprises preparing a mixture of finely divided phosphate rock and a culture medium for bacteria, said mixture being inoculated with nitro-bacteria and said culture medium constituting a relatively large proportion of the mixture, and incubating the mixture.

18. The process of preparing a fertilizer which comprises preparing a mixture of finely divided phosphate rock, humus-like material, and agents promoting bacterial growth, the mixture being inoculated with cultures of several different kinds of nitro-bacteria, and the phosphate rock constituting not more than about one-half of the mixture, and maintaining the mixture at approximately 25° C. for a period of time sufficient to effect extensive conversion of the phosphate rock.

19. A fertilizer composition comprising humus-like material inoculated with nitro-bacteria and containing an added promoter of bacterial activity, in intimate mixture with a finely divided mineral naturally containing plant food in unavailable form but modified *in situ* by said inoculated material.

20. A fertilizer composition comprising inoculated humus material intimately admixed with phosphate rock chemically modified by said inoculated humus material.

21. A fertilizer composition comprising humus material inoculated with nitrifying and nitrogen-fixing bacteria, intimately admixed with phosphate rock chemically modified by said inoculated humus material.

22. The process of preparing a fertilizer which comprises subjecting a mixture of natural phosphatic and potassiferous minerals to the decomposing action of nitro-bacteria in the presence of a food for bacteria.

23. The process of preparing a fertilizer which comprises growing nitro-bacteria and lactic acid bacteria in a mixture comprising a food for bacteria and a mineral containing plant food.

24. The process of treating mineral matter to render more available plant food contained therein, which comprises growing bacteria in a mixture comprising said mineral matter, a bacteria food, and sulfur, the bacteria employed being capable of acting in the mixture to render the contained plant food more available.

25. The process of treating mineral matter to render more available plant food contained therein, which comprises growing nitro-bacteria in a mixture comprising said mineral matter, a bacteria food, and sulfur.

26. The process of treating phosphatic mineral matter to render available phosphoric acid contained therein, which comprises growing nitro-bacteria in a mixture comprising said mineral matter, a nutrient medium, and sulfur.

27. The process of treating phosphate rock which comprises subjecting phosphate rock to the decomposing action of a slightly alkaline culture medium containing sulfur and inoculated with suitable nitro-bacteria.

28. The process of treating mineral matter to render available plant food contained therein, which comprises growing nitro-bacteria in a mixture comprising such mineral matter and a malt nutrient.

29. The process of treating mineral matter to render available plant food contained therein, which comprises growing nitro-bacteria in a mixture comprising such mineral matter and ground sprouted barley.

30. A fertilizer composition comprising fertilizer-containing mineral matter mixed with nutrient and carrier material containing sulfur and carrying bacteria capable of acting in the mixture to render more available fertilizer contained in said mineral matter.

31. A fertilizer composition comprising phosphate rock, mixed with nutrient and carrier material containing sulfur and carrying bacteria capable of acting in the mixture to render the phosphoric acid content thereof more available.

32. A fertilizer composition comprising phosphate rock, mixed with nutrient and carrier material containing sulfur and carrying nitrifying bacteria.

33. A fertilizer composition comprising phosphate rock, mixed with nutrient and carrier material containing sulfur and carrying ammonifying, nitrifying and nitrogen-fixing bacteria.

34. The process of preparing a fertilizer material which comprises preparing a mixture of a finely-divided phosphatic mineral with selected nitro-bacteria and a food for

aid bacteria, and maintaining the mixture
t a temperature not substantially less than
bout 25° C. to promote development of said
acteria and thereby to render the phos-
horic acid content of said mineral more
vailable.

35. The process of preparing a fertilizer
aterial which comprises subjecting mate-
rial containing compounds of both phos-
phorus and potassium chiefly in relatively
unavailable form to the decomposing action
of selected bacteria in the presence of a food
for bacteria.

In testimony whereof I hereunto affix my signature.

GEORGE H. EARP-THOMAS.

UNITED STATES PATENT OFFICE.

THOMAS FRANKLIN MANNS, OF NEWARK, DELAWARE.

PROCESS OF REINFORCING, BACTERIZING, AND COMPOSTING ORGANIC MATERIAL FOR USE AS INOCULATORS, IMPROVERS, AND FERTILIZER OF SOILS.

1,320,701. Specification of Letters Patent. Patented Nov. 4, 1919.

No Drawing. Application filed October 18, 1915. Serial No. 56,040.

To all whom it may concern:

Be it known that I, THOMAS F. MANNS, a citizen of the United State, residing at Newark, in the county of New Castle and State of Delaware, have invented certain new and useful Improvements in Processes of Reinforcing, Bacterizing, and Composting Organic Materials for Use as Inoculators, Improvers, and Fertilizer of Soils, of which the following is a specification.

This invention relates to a process of reinforcing, bacterizing, and composting organic material, such as peat, muck, manure, and the like for use as a soil inoculator, soil mellower, plant stimulator and fertilizer.

I have discovered that peat, muck, manure, weed compost or other organic material can be transformed into a fertilizer containing an accumulation of nitrate nitrogen by bacterial action and a humus content having a high stimulative influence on plant life and possessing great value as a plant food, a soil improver and fertilizer, by reinforcing or adding to the organic matter, phosphorus in the form of basic slag, or potassium, sodium or calcium phosphate, either the neutral or acid forms, but preferably the commercial calcium acid phosphate, and then by the addition of a base, either wood ashes, basic slag, potassium carbonate, calcium carbonate or hydrate, but preferably calcium hydrate with certain amounts of wood ashes, basic slag and potassium carbonate, to neutralize the mixture, and then by bacterizing and composting.

The practice of my process will be described in connection with the treatment of peat but it is to be understood that it is equally applicable to other organic materials.

In the practical application of my process to the treatment of peat there are produced two important products each having a high commercial value. The first product, which I shall refer to herein as the bacterial compost, bacterizer or inoculator, is a rich compost containing all the known beneficial soil bacteria. This product, when partially air dried without destroying the beneficial organisms contained therein, is used to abundantly inoculate the second product which is peat or other organic matter sufficiently dried, and reinforced with proper mineral and organic compounds. The latter product is sent out commercially in a partially dried state which, when moistened in the soil to which it is applied, will set up bacterial action from the thorough inoculation. Soil inoculation and plant stimulation will result bringing high crop response.

In the practical application of my process, in the production of the first product, viz., the bacterial compost or bacterizer, I add to peat or other organic matter, a phosphate, either the neutral or acid phosphates of sodium, potassium or calcium or Thomas slag, but preferably a sixteen per cent. (16%) commercial calcium acid phosphate, and a sufficient quantity of some alkali metal or alkaline earth metal compound to neutralize the product, such as basic slag, calcium, sodium, or potassium carbonate, or the hydrates of these alkalis or alkaline earths, but preferably a mixture of calcium carbonate, calcium hydrate, basic slag and wood ashes, to which entire mixture is added a quantity of a carbohydrate such as molasses or sugar and protein matter such as dried blood, tankage, cottonseed meal or similar organic matter. At the time of mixing, the proper bacterial flora is supplied through a mixture of soils known to contain an abundance of the desired organisms. In case the soils used are deficient in any of the desired legume organisms pure cultures may be used.

I have found that a satisfactory compost will result from a mixture of peat, calcium phosphate or calcium acid phosphate, and calcium carbonate, or a mixture of substantially equal parts of calcium carbonate and calcium hydrate and inoculated soils in the following proportions:

Peat	1 ton.
Commercial calcium acid phosphate	50 lbs.
Calcium hydrate	50 lbs.
Soils, well inoculated	25 lbs.

In my experiments with my process I have found it advantageous to add the alkali metal or alkaline earth metal salts in sufficient quantity to overcome the acidity of the acid phosphate added and the peat or other organic material under treatment. I have also found that improved results may be obtained by the use of additional mineral materials, such for example as potassium

salts, notably potassium chlorid, potassium sulfate and potassium carbonate, wood ashes and Thomas slag. I have also found it advantageous to add to the mixture of peat and mineral matter a liberal amount of molasses or sugar, and dried blood, preferably 30 pounds of the former and 10 pounds of the latter to each ton of organic matter.

I have obtained particularly advantageous results in my bacterial compost or bacterizer, from the use of peat, calcium, acid phosphate (commercial) calcium phosphate (commercially known as "floats"), calcium hydrate, calcium carbonate, wood ashes, Thomas slag, molasses and dried blood, and properly inoculated soil in the following proportions by weight:

Peat	1 ton.
Calcium acid phosphate	5 lbs.
Rock phosphate (known commercially as "floats")	50 lbs.
Calcium hydrate	20 lbs.
Calcium carbonate (ground limestone)	100 lbs.
Wood ashes	200 lbs.
Thomas slag	10 lbs.
Dried blood	10 lbs.
Molasses (or cane sugar 25 lbs)	30 lbs.
Well inoculated soil	25 lbs.

The peculiar efficiency of this bacterial compost is believed to be due primarily to the well balanced mixture containing all the ingredients or compounds needed for the intended purpose, such ingredients being properly proportioned to give rapid growth to each of the groups of beneficial soil bacteria. I obtain a further advantage from the inoculating material which I employ. This inoculating material is preferably selected soils from widely different areas of the United States, definitely proven for their efficiency in regard to certain physiological activity, (for example, nitrogen fixation; cellulose destruction in which the cellulose becomes food for further bacterial action; the changing of organic nitrogen compounds to ammoniacal and nitric nitrogen). Some of the sources of this inoculating material are as follows: For azotobacter, that is the non-symbiotic nitrogen fixing organisms, and nitrosomonas and nitrobacter, the former oxidizing ammonia to nitrite, and the latter completing the oxidation to nitrate, I use the active azo or nitrogen fixing soils of Colorado and North Dakota, those soils bordering on the so called "niter-spots". For introducing the cellulose destroyers *B. rossica* and related bacteria I use a mixture of rapidly composting manure or a soil known to be high in these organisms. For introducing the ammonifiers I use a soil of high ammonifying efficiency as proven by the destruction of paper, inserted therein. For introducing the legume bacteria I use a well inocula[illegible] soil upon which has grown the partic[illegible] legume for which the inoculation is int[illegible]duced. Recent scientific knowledge (Bu[illegible]letin 184, Kentucky Aug. 1914) and (*Centr[illegible]blatt für Bakt.* 40 Bd. No. 11-13—M[illegible] 1914) has shown that there are only [illegible] species of *B. radicicola* and six of th[illegible] species or physiological groups cover [illegible] inoculation of the most important agric[illegible]tural legumes. So in practice I emp[illegible] thoroughly inoculated soil from a legum[illegible] each of the six groups, thereby introduc[illegible] inoculation for all the important agric[illegible]tural legumes in the one compost. In pr[illegible]tice this material has been found supe[illegible] to the so called "pure culture legume inoc[illegible]lating material." In practice, when it [illegible] difficult to obtain the soil well inoculated [illegible] the particular legume, I use a pure cult[illegible] for the same purpose, though the soil gi[illegible] superior results. In practice I find th[illegible] product to give thorough inoculation to th[illegible] following legumes, viz: alfalfa, [illegible] clover (white), sweet clover (yellow), black medic or yellow trefoil, bur clov[illegible] red clover, mammoth clover, alsike clov[illegible] white clover, soy beans, cow peas, sw[illegible] peas, spring vetch, garden peas, Canada fi[illegible] peas, lima beans, navy beans, velvet be[illegible] and the various other legumes commo[illegible] grown as soil improvers.

In practice the peat or other organic ma[illegible]ter to be composted, the reinforcing [illegible] balancing minerals and compounds (excep[illegible]ing the calcium hydrate which is added [illegible] the well diluted mixture of molasses), th[illegible] dried blood and the inoculated soil whi[illegible] in the preferred embodiment of my inve[illegible]tion contains all the beneficial bacte[illegible] herein before specified, are thorough[illegible] mixed by hand using shovels, or the wh[illegible] mixture is passed through any efficient fe[illegible]tilizer mixer; the material is then spre[illegible] out and the solution of molasses contain[illegible] the lime hydrate is evenly sprayed on, th[illegible] the material is spread out to a depth [illegible] preferably from two to four feet and mo[illegible]tened down by a Skinner irrigation sys[illegible] or other means of watering and allowed [illegible] undergo aerobic composting for two we[illegible] to three months. The product is exami[illegible] from time to time, and when the bacte[illegible] flora has reached the growth required th[illegible] product is ready for use for field, lawn [illegible] garden inoculation, for legume inoculati[illegible] and for inoculating the commercially re[illegible]inforced and balanced peat. The prod[illegible] may be used as a soil in green houses, co[illegible]servatories, or homes. Also in fields as [illegible] general fertilizer, soil inoculator and [illegible] improver.

In practice the composting operati[illegible] may be advantageously concluded when [illegible] *radicicola* is found to be present to th[illegible]

umber of approximately 200 billions per ound of the moist compost. It has been ound in practice that when *B. radicicola* as developed to the extent indicated, the zotobacters are present in approximately 0 billions per pound of moist compost and itrosomonas and nitrobacter are present in pproximately 25 billions. The ammoni- ers and cellulose destroyers approach the atter numbers viz., about 25 billions per ound of moist compost.

It has been found that the addition of ineral materials herein before referred to, articularly in the proportions specified, roduce a balanced material and a bacterial edium particularly suitable for the growth f a well balanced and efficient bacterial ora in which each of the beneficial groups eep pace with one another in an environ- ent conducive to symbiotic relationship.

It has been found in practice that in two eeks of composting a considerable quantity f nitrate nitrogen is formed, equivalent or- inarily to over one pound of nitrates to ach ton of compost. Likewise I have found n practice an accumulation of nitrogen by he activity of the nitrogen fixing organ- sms, equivalent ordinarily to about one ound of high protein matter per ton of ompost in one month. The addition of he alkali or alkaline earth metal phosphate nd the other ingredients mentioned in the articular mixture above set forth produces particularly favorable condition in the edium or material for the rapid and ex- nsive development of *B. radicicola*, *zotobacter chroococcum* and related bac- ria, nitrosomonas and nitrobacter, all rganisms of great importance to agricul- ure, in a desired and particularly advan- ageous relationship as to the development f each.

In the practice of my process I have ound that there is a close symbiosis be- ween *B. radicicola* and *Azotobacter chroo- occum* and especially that the gummy or elatinous exude of *B. radicicola* is a fa- orable medium in which to develop.

My second product consists in reinforced balanced peat that has been inoculated bacterized with the bacterial compost or acterizer. This second material or rein- orced and inoculated or bac rized peat is ot composted previous to placing it on the arket. The reinforcement or addition of ineral and or anic compounds make it at nce a valuable fertilizer and a favorable edium for bacterial development, as soon it is moistened. In the practical appli- ation of my process in producing this prod- t, the peat is partially dried, preferably movement over a rotary drier, it is then ound fine, and the reinforcing material dded. This material is added in sufficient uantity to make the product an immedi- ately responsive fertilizer and at the same time a very favorable medium or food for the rapid development of the beneficial bacteria which have been applied. My second mixture is preferably made in approxi- mately the following proportions:

Peat	1800 lbs.
High grade tankage	40 lbs.
Floats (ground rock phosphate)	60 lbs.
Acid phosphate (commercial 16% acid phosphate)	20 lbs.
Wood ashes (8% potash)	100 lbs.
Lime hydrate	20 lbs.
Nitrate of soda (18% nitrate)	10 lbs.
Granulated sugar	3 to 10 lbs.
Bacterial compost or bacterizer	50 lbs.

In practical application this product is found to give to plants a high fertilizing response. It is very effective in mellowing heavy clays and retaining moisture and holding together sands. It is especially efficient on lawn and turfs. It is also highly stimulating to field crops, such as wheat, other grains and grasses and is very valuable as a truck crop stimulator. It has been found in practice to give thorough inoculation to all soils to which applied and all agricultural legumes take a thoroughly satisfactory inoculation. This is an advantage which it is believed is not possessed by any other single material intended for the same purpose.

The cost of the ingredients employed in my process and the inexpensiveness of the operation makes it possible in practice to sell this product commercially at such a low price per ton that it may be used freely as a field fertilizer as well as a soil inoculator and a soil improver.

It is to be understood that the present invention is not restricted to the illustrative examples herein before set forth, it being understood that known equivalents of the materials may be used, nor to the proportions of the ingredients specified nor to the exact details of procedure set forth, it being understood that these may be varied without departing from the spirit of my invention or the scope of the subjoined claims.

Having thus described the invention, I claim:—

1. The herein described process of producing a bacterial compost or bacterizer containing organisms necessary for the inoculation of the different agricultural legumes which consists in mixing peat-like organic material of the character specified, a phosphate, a base in sufficient amount to produce a substantially neutral mixture, protein matter and carbo-hydrate matter, inoculating the mixture with azotobacters, *B. radicicola*, nitrobacters, and *B. rossica*, and composting the mixture.

2. The herein described process of producing a bacterial compost or bacterizer containing organisms necessary for the inoculation of the different agricultural legumes which consists in adding to peat-like organic material of the character specified, a phosphate, a base in sufficient amount to produce a substantially neutral mixture, dried blood and sugar, inoculating the mixture with azotobacters, *B. radicicola*, nitrobacters, and *B. rossica*, and composting the mixture.

3. The herein described process of producing a bacterial compost or bacterizer containing organisms necessary for the inoculation of the different agricultural legumes which consists in thoroughly mixing unsterilized peat, a phosphate, a base in sufficient amount to produce a substantially neutral mixture, dried blood and sugar, inoculating the mixture by the addition thereto of a mixture of soils well inoculated with azotobacters, *B. radicicola*, nitrobacters, and *B. rossica*, and composting the mixture.

4. The herein described process of producing a bacterial compost or bacterizer containing organisms necessary for the inoculation of the different agricultural legumes which consists in thoroughly mixing peat, calcium acid phosphate, calcium hydrate, sugar and dried blood in approximately the following proportions: peat 1 ton, calcium acid phosphate 50 lbs., calcium hydrate 50 lbs., sugar 25 lbs., and dried blood 10 lbs., inoculating the mixture with azotobacters, *B. radicicola*, nitrosomonas, nitrobacters, and *B. rossica*, and composting the mixture.

5. The herein described process of producing a bacterial compost or bacterizer containing organisms necessary for the inoculation of the different agricultural legumes which consists in thoroughly mixing peat, calcium acid phosphate, rock phosphate, calcium hydrate, calcium carbonate, wood ashes, Thomas slag, sugar and dried blood, inoculating the mixture with azotobacters, *B. radicicola*, nitrosomonas, nitrobacters, and *B. rossica*, and composting the mixture.

6. The herein described process of producing a bacterial compost or bacterizer containing organisms necessary for the inoculation of the different agricultural legumes which consists in thoroughly mixing peat and the following materials in substantially the proportions specified: to each ton of peat, calcium acid phosphate 5 lbs., rock phosphate 50 lbs., calcium hydrate 20 lbs., calcium carbonate 100 lbs., wood ashes 200 lbs., Thomas slag 10 lbs., sugar 25 lbs., and dried blood 10 lbs., inoculating the mixture with azotobacters, *B. radicicola*, nitrosomonas, nitrobacters, and *B. rossica*, and composting the mixture.

7. The herein described process of producing a bacterial compost or bacterizer containing organisms necessary for the inoculation of the different agricultural legumes which consists in adding to peat-like organic material of the character specified, a phosphate, a base in sufficient amount to produce a substantially neutral mixture, carbohydrate matter and protein matter, inoculating the mixture with organisms of a plurality of groups of beneficial soil bacteria, composting the mixture, and adding a portion of the resulting product to a mixture of peat-like organic material of the character specified, rock phosphate, calcium acid phosphate, wood ashes, calcium hydrate, sodium nitrate, carbo-hydrate and protein matter.

8. The herein described process of producing a bacterial compost or bacterizer containing organisms necessary for the inoculation of the different agricultural legumes which consists in thoroughly mixing peat and the following materials in substantially the proportions specified; to one ton of peat, calcium acid phosphate 5 lbs., rock phosphate 50 lbs., calcium hydrate 20 lbs., calcium carbonate 100 lbs., wood ashes 200 lbs., Thomas slag 10 lbs., sugar 25 lbs., and dried blood 10 lbs., inoculating the mixture by adding a mixture of soils well inoculated with azotobacters, *B. radicicola*, nitrosomonas nitrobacters, and *B. rossica*, composting the mixture and adding a portion of the product to a mixture of peat with the following materials, in substantially the proportions specified: to 1800 lbs. of peat, rock phosphate 60 lbs., commercial calcium acid phosphate 20 lbs., sodium nitrate 10 lbs., granulated sugar, 3 to 10 lbs., high grade tankage 40 lbs.

9. The herein described bacterial compost or bacterizer containing organisms necessary for the inoculation of the different agricultural legumes, containing peat, a phosphate, a base in sufficient amount to produce a substantially neutral mixture, protein matter and carbo-hydrate matter, such material being thoroughly inoculated with azotobacters *B. radicicola*, nitrosomonas, nitrobacters and *B. rossica*.

10. The herein described bacterial compost or bacterizer containing organisms necessary for the inoculation of the different agricultural legumes, comprising peat, commercial calcium acid phosphate, calcium hydrate, sugar and dried blood in substantially the following proportions: peat, one ton, calcium acid phosphate 50 lbs., calcium hydrate 20 lbs., sugar 25 lbs., dried blood 10 lbs., said material being thoroughly inoculated with azotobacters, *B. radicicola*, nitrosomonas, nitrobacters, and *B. rossica*.

11. The herein described bacterial compost or bacterizer, containing organisms necessary for the inoculation of the different

agricultural legumes, containing the following materials in substantially the proportions specified: peat 1 ton, commercial calcium acid phosphate 5 lbs., rock phosphate 50 lbs., calcium hydrate 20 lbs., calcium carbonate 100 lbs., wood ashes 200 lbs., Thomas slag 10 lbs., sugar 25 lbs., protein matter 10 lbs., the material being well inoculated with azotobacters, *B. radicicola*, nitrosomonas, nitrobacters, and *B. rossica*.

In testimony whereof I affix my signature in presence of two witnesses.

THOMAS FRANKLIN MANNS.

Witnesses:

Mrs. ALYS MANNS,

M. R. APSLEY.

1231 UNITED STATES OF AMERICA
SOUTHERN DISTRICT OF ILLINOIS } ss:
SOUTHERN DIVISION

I, G. W. Schwaner, Clerk of the District Court of the United States in and for the Southern District of Illinois and keeper of the records and the Seal thereof, do hereby certify the foregoing to be a true and complete transcript of the proceedings had of record and on file in the cause entitled KALO INOCULANT COMPANY, A CORPORATION *vs.* FUNK BROTHERS SEED COMPANY, A CORPORATION, CIVIL ACTION NUMBER Q-62, made in accordance with the Stipulated Designation of Record on Appeal, as fully as the same appear from the original files and records thereof now in my office remaining. And I further certify that in accordance with the Stipulation of counsel approved by the court, the original transcript of the Record of Proceedings at the Trial has been incorporated in the said transcript of record on appeal.

IN TESTIMONY WHEREOF, I have hereunto subscribed my name and affixed the Seal of the aforesaid Court, at Quincy, this 1st day of March, A. D. 1946.

G. W. Schwaner Clerk.

(Seal)

UNITED STATES CIRCUIT COURT OF APPEALS

For the Seventh Circuit.

I, Kenneth J. Carrick, Clerk of the United States Circuit Court of Appeals for the Seventh Circuit, do hereby certify that the foregoing printed pages contain a true copy of Volume 2 of the Printed Record, being one of 2 Volumes of said Printed Record filed on October 19, 1946, in:

Cause No. 9040-41.

Kalo Inoculant Company,
Plaintiff-Appellant,

vs.

Funk Brothers Seed Company,
Defendant-Appellee,

and

Kalo Inoculant Company,
Plaintiff-Appellee,

vs.

Funk Brothers Seed Company,
Defendant-Appellant,

as the same remains upon the files and records of the United States Circuit Court of Appeals for the Seventh Circuit.

In Testimony Whereof I hereunto subscribe my name and affix the seal of said United States Circuit Court of Appeals for the Seventh Circuit, at the City of Chicago, this 1st day of August, A. D. 1947.

Kenneth J. Carrick,
(Seal) *Clerk of the United States Circuit Court of Appeals for the Seventh Circuit.*

At a regular term of the United States Circuit Court of Appeals for the Seventh Circuit, held in the City of Chicago, and begun on the second day of October, in the year of our Lord one thousand nine hundred and forty-five, and of our Independence the one hundred and seventieth.

Kalo Inoculant Company,
Plaintiff-Appellant,
9040 *vs.*
Funk Brothers Seed Company,
Defendant-Appellee.

Kalo Inoculant Company,
Plaintiff-Appellee,
9041 *vs.*
Funk Brothers Seed Company,
Defendant-Appellant.

Appeals from the District Court of the United States for the Southern District of Illinois, Southern Division.

And afterwards, to-wit: On the eighth day of May, 1947, the following proceedings were had and entered of record, to-wit:

Thursday, May 8, 1947.

Court met pursuant to adjournment.

Before:

Hon. Evan A. Evans, Circuit Judge.
Hon. J. Earl Major, Circuit Judge.
Hon. Walter C. Lindley, District Judge.

Kalo Inoculant Company, *Plaintiff-Appellant,* vs. Funk Brothers Seed Company, *Defendant-Appellee.* 9040	Appeals from the District Court of the United States for the Southern District of Illinois, Southern Division.
Kalo Inoculant Company, *Plaintiff-Appellee,* vs. Funk Brothers Seed Company, *Defendant-Appellant.* 9041	

Now this day come the parties by their counsel, and this cause comes on to be heard on the transcript of the record and the briefs of counsel, and on oral argument by Mr. J. Bernhard Theiss for the Kalo Inoculant Company, and by Mr. H. A. Toulmin, Jr. for the Funk Brothers Seed Company, and the Court takes this matter under advisement.

And afterwards, to-wit: On the twelfth day of June, 1947, there was filed in the office of the Clerk of this Court, the Opinion of the Court, which said opinion is in the words and figures following, to-wit:

IN THE UNITED STATES CIRCUIT COURT OF APPEALS

For the Seventh Circuit.

October Term, 1946, April Session, 1947.

KALO INOCULANT COMPANY, *Plaintiff-Appellant,* vs. FUNK BROTHERS SEED COMPANY, *Defendant-Appellee.* — No. 9040.	Appeals from the District Court of the United States for the Southern District of Illinois, Southern Division.
KALO INOCULANT COMPANY, *Plaintiff-Appellee,* vs. FUNK BROTHERS SEED COMPANY, *Defendant-Appellant.* — No. 9041.	

June 12, 1947.

Before EVANS, MAJOR, *Circuit Judges,* and LINDLEY, *District Judge.*

LINDLEY, *District Judge.* Plaintiff, manufacturer and vendor of bacterial inoculant for leguminous plants, brought suit for infringement of patent to Bond No. 2,200,532, issued May 14, 1940, on application filed August 24, 1938, and assigned to plaintiff, against defendant, wholesale and retail dealer in certain leguminous inoculants, alleged to be infringing products manufactured by The Agricultural Laboratories, Inc., of Columbus, Ohio, who assumed control and direction of the defense. The District Court adjudged the claims upon which plaintiff relied invalid for want of invention, finding, however, that, if they were valid, defendant infringed. The court dismissed defendant's counter-

claim for declaratory judgment of invalidity of all claims of the patents, including those in suit. Plaintiff appeals from the judgment of invalidity and defendant from the dismissal of its cross-complaint.

The essential facts, as reflected by the court's findings, are not largely in dispute. The patent contains 14 claims. Those in suit 1, 3, 4, 5, 6, 7, 8, 13 and 14 and 2, not in suit, are product claims.* The others, 9, 10, 11 and 12, are process or method claims. The patent is entitled "Bacterial Inoculant for Leguminous Plants." Its descriptive matter includes recital of scientific facts, then known to scientists delving in the art, and prescribes certain old conventional tests necessary in successful production of bacteria for leguminous plants. The claims cover a composite culture in which are included a plurality of species of bacteria belonging to the general Rhizobium genus, carried in a conventional base. The claim of invention rests primarily upon the fact that each separate culture of the several different species included in the composite inoculant is unaffected by the presence of others in its ability to fix nitrogen in the leguminous plant for which it is specific. It is undisputed that bacteria of this genus promote nitrogen fixation in leguminous plants and are found in nature. The precise mechanism of nitrogen fixation is not understood, but it has been well known for many years that it can be achieved only when the plant grows in symbiotic relationship with certain bacteria of the genus. Leguminous plants capable of such relationship with Rhizobia include peas, beans, alfalfa, red clover, white clover, vetch, lupines and others. When nitrogen is collected or fixed, it appears in the form of nodules on the roots of the plants; the bacteria infect the roots, causing formation of the nodules in which nitrogen fixation occurs. Scientists have known for a long time that Rhizobium bacteria promote nitrogen fixation when a certain species or strain of the same is applied in symbiotic relationship to the leguminous plant of the cross inoculation group to which the particular species or strain is specific. Manufacturers of inoculants have, for a long time, taken these bacteria as found in nature, where they perform this nitrogen fixation, and, by well known

*Claim 4, we think, is typical of this group. It reads: An inoculant for leguminous plants comprising a plurality of selected mutually non-inhibitive strains of different species of bacteria of the genus Rhizobium, said strains being unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

laboratory methods of culture, increased their number, changing in no way their shape, form or characteristics, physiologically or otherwise, placed them in a powder or liquid base, as a carrying medium, and sold them for use by agriculturists in the inoculation of leguminous plants. Bond claims to be the first successfully to combine different species of the genus in one composite product so that each species will continue to perform its functions when brought into its proper symbiotic relationship. In other words, a specific species of the genus Rhizobium, functioning with its corresponding species of legume in an inoculant for its specific species of legume had, as we have said, been successfully produced and used with desirable results. As to the facts thus far related, we think there is no substantial dispute.

Bond does not claim to have invented any new species of Rhizobium bacteria but, as the District Court found, he discovered that among the bacteria found widely spread in nature there exist not only mutually inhibitive species but also mutually noninhibitive strains which can be selected and isolated and, when so selected, isolated and combined, continue to perform the same functions that they do in nature. The method of culture of single strains of bacteria described in Bond's patent and his method of placing bacteria in a carrying medium or base were well known in the art. So, too, was the proper character of the base or carrying medium. In fact, Bond's claim of invention arises from his averment of discovery that, though in the bacteria genus Rhizobium some species, when combined with others, had an injurious or adverse effect upon each other, when properly selected and combined, certain of them were noninhibitive of each other. This inhibitive character of certain species was already known to scientists, but, he added to that knowledge his own discovery, as a result of empirical tests, that there are also strains or species of bacteria involved which are noninhibitive of others, in other words, that there are noninhibitive cooperative strains as well as inhibitive, destructive strains. Thus he said: "It has heretofore been considered impractical to prepare a composite inoculant containing organisms which will cause nodulation on more than one of the cross inoculation groups. This has not been done because it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic

nitrogen fixation by the plant and the organism was inhibited or even prevented." His teaching was that he could, by conventional tests, delete the inhibitive strains and retain the noninhibitive ones and that these, when combined, could be put into a composite inoculant where the same desirable results could be achieved by each appropriate species of bacteria as would be accomplished if only a single species of bacteria were included in the inoculant. Upon this we think the question of invention hinges.

The District Judge thought invention was not achieved, saying that he found the claims invalid because they did not involve invention or discovery of any new or useful art. This, he said, he did "with reluctance," as he was impressed with the very "great diligence and ingenuity" of Bond and with the results he had achieved. But, though Bond's work was not to be minimized, the Judge believed it could not be classified under any subject defined as patentable by the Congressional Act. However, he made a specific finding that Bond did discover that there exist in nature noninhibitive strains and that these noninhibitive strains may be selected, isolated and combined and still perform satisfactorily their ordinary desirable functions. Upon this finding there was controverted evidence, but our examination of the record is convincing that that supporting the finding is rather conclusive and that there is no justification for us to declare the District Court in error in making it. Consequently the specific question which now confronts us is whether, upon the finding of fact, the court erred in concluding that, under the law, Bond made nothing patentable.

We have previously said that Bond recognized everything that had been done by scientists delving in this art prior to his application. He knew that bacteriologists were well informed as to the conventional tests and the essentials of development of a bacterial culture and possessed all the knowledge necessary to successful isolation and culture of bacteria. He recognized that prior delvers in the art were aware of proper *media* for lodgment and distribution of cultures fully developed and ready for commercial use. He made no claim to have discovered in nature any species of bacteria not previously known. He knew that the different species properly suitable for the several functions to be performed had been thought to be mutually inhibitive. He did discover the fact, as the court found,

that there are strains proper for the desired purpose of combination which possess no antagonistic characteristics which, when combined, do not tend to suppress the growth of any of other species, all of which, when combined, develop in wholly noninhibited, unimpeded growth. He emphasized the fact that composite inoculants had not been successful previously and that this was generally but erroneously thought to be because the various strains when combined always inhibited each other.

This, he said, was the status of the art when in June, 1937, he first discussed with the president of his company the possibility of the manufacture of a practical composite or mixed leguminous culture. He was familiar at that time with adverse opinion of authorities in the field in regard to mixed cultures. During that summer he attended the University of Wisconsin and there investigated the literature in the library of the College of Agriculture. In his research he found adverse references to the use of mixed cultures containing more than one species of leguminous organisms and learned that it had been publicly reported that when two or more different species were mixed, they had a definite antagonistic effect upon each other which reduced their ability to benefit the host plant. He testified that he found nothing to indicate that anyone had ever thought that there were in existence strains or species in which inhibition did not exist. The known teaching, so far as he could discover at that time, was that a species of the genus might be "very good when used alone, * * * be very beneficial, * * * be a highly efficient strain, but, when mixed with other strains would become less efficient and produce a lower yield than the same strain when used alone." The so-called Bible of the inoculant art, "Root Nodule Bacteria and Leguminous Plants," by Fred, Baldwin and McCoy, University of Wisconsin Studies in Science, Number 5, 1932, reported that composite cultures "offer advantages and many disadvantages" and that "it is desirable to have only the one type of organism in the culture."

Bearing in mind that the District Court found specifically that Bond discovered that there are noninhibitive strains of the proper species of bacteria as well as inhibitive species and that Bond had been greatly diligent and ingenious, it becomes obvious, we think, that he made an inventive step forward in the art of production and commercial distribu-

tion of composite inoculants. It was desirable, as he pointed out in his patent, that farmers should have one composite inoculant which could be used in producing their different crops. In such case it would be unnecessary for dealers to keep in inventory and for the farmer to buy, preserve and maintain several different inoculants. His company was hopeful that he could manage to produce such a satisfactory composite inoculant. His problem was to find a method by which he might get away from the inhibitive, antagonistic, impeding characteristics of the different strains of bacteria when combined and, at the same time, produce a composite that would contain and maintain the proper number of live and active bacteria of each species throughout the useful life of the product. This problem had not been solved by any one and it apparently daunted Bond, for, at first, it appeared insoluble. However, in the course of continued probing, he made the discovery which nobody, prior to that time, had uncovered, namely, that there exist in nature certain strains of nodule bacteria which do not assert an inhibitive and antagonistic effect on each other and that such mutual noninhibitive strains can, by well known methods, be selected and isolated for use in a mixed culture so that the final composite product will contain, throughout its desirable life, a sufficient number of live and active bacteria of each species, lodging them in a base material substantially free of nutrients. His scientific investigation led to a proper solution, which we think the evidence shows had baffled the workers in the prior art because of their mistaken assumption of supposedly universal inhibitive effect encountered in mixed cultures. Thus, in making one of his tests, Bond found that one of the proper strains of soy bean bacteria, "Rhizobium Japonicum," was found to produce 34.8% more nitrogen when employed alone on soy bean seed than when employed on the same seed in the presence of clover bacteria and alfalfa bacteria (Rhizobium trifolii and Rhizobium meliloti). He found also that a strain of clover bacteria would produce 119% more nitrogen when employed alone than when employed in the presence of soy bean bacteria and alfalfa bacteria. Inhibitive effect was the restraining factor preventing a successful commercial composite inoculant and this factor he taught the art to avoid by discovering that there are noninhibitive bacteria and teaching that they can be successfully employed, when combined, without in-

jury to any of the other constituent species. Thus he says in his patent: "The composite culture may be prepared by selecting strains of the desired species of the Rhizobia which will produce optimum beneficial results to the host plant and will not be adversely affected by each other." And, that he taught how this might be done is illustrated by this language: "* * * Each of the strains is tested separately with its own host plant in order to select out those which are most effective in respect to the development of the host plant and the quantity of nitrogen fixed thereby. * * * The cultures showing the best results in association with the host plant may then be selected and the various strains of the different species may be mixed together in order to determine if the nitrogen-fixing ability of one species is adversely affected by the mere presence of another, as has been previously thought to be the case. Thus, it has been previously considered that the nitrogen-fixing ability of Rhizobium trifolii in symbiotic relationship with red clover is markedly inhibited if strains of Rhizobium meliloti, Rhizobium japonicum, or other species of the Rhizobia were present within the same inoculant. It has been found, however, that, by a suitable process of selection of strains in the manner indicated above, a composite culture may be obtained which may be used to effect a plurality of cross-inoculation groups with optimum results."

For convenience sake, he designated the noninhibitive strains as "alpha" organisms and said that he had discovered no method by which they might be differentiated from the mutually inhibitive group of Rhizobia other than by making actual nitroger fixation tests by inoculating the various host plants with the proposed mixture of the Rhizobia. But by "alpha" strains he did not mean that he had discovered a new bacteria but merely that certain existing bacteria are noninhibitive.

The mistake of the District Court, we think, lay in its conclusion that this did not amount to patentable invention within the meaning of the statute. Though the court recognized the value of Bond's work, it thought that he had merely discovered a law of nature, whereas in fact the evidence is clear that what he discovered was that certain existing bacteria do not possess the mutually inhibitive characteristics which had previously prevented a successful commercial composite inoculant and that those unin-

hibitive species may be successfully combined. It was this contribution of noninhibitive strains which successfully combine that brought about a new patentable composition. This was application of scientific knowledge to things existing in nature and the utilization of them in a desirable composite product which had not been previously achieved but which he did achieve and of which the public now has the benefit.

We think this is clearly within the decisive definitions of patentable invention. It is in accord with the decision of this court in *Dennis et al.* v. *Pitner et al.*, 106 F. 2d 142 (CCA7) and that of the Supreme Court in *Mackay Radio & Tel. Co.* v. *Radio Corp.*, 306 U. S. 86. See also *Union Carbide Co.* v. *American Carbide Co.*, 181 F. 104; *J. E. Baker Co.* v. *Kennedy Refractories Co.*, 253 F. 739 (CCA3). Bond taught the method by which the composite is to be made and claims the product composed by that method, namely, a composite inoculant, comprised of different species of bacteria in sufficient numbers of each species. The noninhibitive property of bacteria was not previously known and when Bond discovered it and taught a successful composition of noninhibitive strains in combination of elements in one inoculant operating successfully on several different groups of legumes, he did much more than discover a law of nature. He made a new and different composition, one contributing utility and economy to the manufacture and distribution of commercial inoculants. As this court said, in *Dennis et al.* v. *Pitner et al.*, *supra*, the discovery of a natural phenomenon, or of a quality or attribute of a well known article and application of that quality in a successful combination which is of value to mankind, is entitled to patent protection. We adhere to that pronouncement and we think Bond achieved that end.

Defendant has directed our attention to certain prior art patents, publications and uses, all of which we have studiously examined. We might discuss them at length, but we think it sufficient to say that the sum total of all of the prior teaching is that mixed inoculants had been in existence before but that they had been composed by hit and run methods without regard to whether the various species included in the composite worked adversely to one another or inhibited one another in their respective growths. Some of them may have been successful, because, by mere chance, only noninhibitive species were included. Some of them

must have been wholly useless when they included only inhibitive species, and the result must have been far from satisfactory when they included both inhibitive and non-inhibitive species. Nothing in the art suggests the slightest conception of Bond's solution of the problem.

Defendant insists also, as it did in the District Court, that the patent is either the invention of Lusk or the joint invention of Lusk and Bond. The District Court found that, though the general idea of the desirability of a composite culture was suggested by Lusk, the discovery of the concrete solution of the problem was the act of Bond and that the invention or discovery, if any, was his sole act. We agree with the court that, under the evidence, all that Lusk did was to suggest that it would be highly desirable for his company to have a composite inoculant such as Bond later invented; that Lusk had no conception of what the problem really involved or of how to solve it and that all of the investigation, research and thought leading to its solution was the work of the patentee. Certainly it can not be said that, upon the evidence in this record, this court is justified in setting aside the finding of the District Court.

Defendant also contends, as it did in the District Court, that the plaintiff misrepresented his application to the Patent Office and, therefore, does not come into court with clean hands. We think there is no evidence justifying a finding to this effect, and again we find that the court made a specific finding in this respect to the effect that Bond believed in the existence of the inhibitive effect of various species at the time he instituted his research and acted in good faith when, in his application for the patent in suit, he said that it had previously been considered impractical to prepare a composite inoculant containing organisms which would produce nodulation on more than one of the cross inoculation groups because it was generally believed that one species produced an inhibitory effect on another species within the same culture, whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented and that plaintiff was not guilty of the charge of unclean hands. We have examined the evidence of what transpired in the Patent Office. We find nothing in the record to justify us in ignoring or declaring erroneous this specific finding of the District Court.

Defendant insists that the description of the patent is insufficient, under 35 U. S. C. A. 33, which requires inventors

to describe clearly their inventions. The District Court did not give any credence to this contention and we do not think we would be justified in declaring the patent invalid because of anything appearing in the record in this respect. True, routine experiments are to be employed, but these tests are conventional and well known to bacteriologists. The mere provision that the compound shall be made of strains or species of bacteria selected by familiar methods leaves nothing indefinite in the description. If noninhibitive strains were readily identifiable in nature as separate species, without scientific tests, of course tests would not be necessary, but no such good fortune confronts the scientist when he starts to isolate bacteria. There is no weight and measure method by which he may determine the quality or quantity of bacteria he is supposed to put into a composite product; there is available only selection by utilization of well known conventional tests. Only the scientist in his laboratory can produce controlled culture of bacteria and he, delving in the art of such culture, must at all times employ the methods found efficient by trained scientists. Where those methods are old and well known to the art, no difficulty is encountered in a description for a patent composite which provides for their utilization or employment. In other words, Bond's tests were manifest to readers skilled in the art. No one so skilled would have any difficulty in determining what he should do when his attention was directed to the necessity of making them. *Eibel Process Co.* v. *Minnesota & Ontario Paper Co.*, 261 U. S. 45, 63. As the Supreme Court has indicated, we think that intelligent bacteriologists, setting out properly to gather together the enumerated ingredients which are prescribed for the composite article, reading the description, could hardly go astray. *Seabury* v. *Am. Ende*, 152 U. S. 561. The requirement that preliminary tests must be made does not invalidate a specific method when their character and limitations are well known to the art. *Minerals Separation, Ltd.* v. *Hyde*, 242 U. S. 261; *A. B. Dick Co.* v. *Barnett*, 288 Fed. 799, 801 (CCA2).

Defendant contends that Bond merely taught how to make an aggregation lacking inventive character. We do not think so. An aggregation achieves nothing new. It is a term engrafted in the patent law either through the ingenuity of counsel or the lexicography of the courts, at a loss for a better term, to connote or express mere

lack of patentable inventive quality in a combination. As said by this court in *Lincoln Engineering Co.* v. *Stewart-Warner Corp.*, 91 F. 2d 757 (CCA7), the term "aggregation" if proper at all is proper as a definition of a phase of the term "non-invention." Where the claim constitutes a plurality of elements and their individual or collective selection fails to evidence the exercise of inventive faculty, it is of course not a patentable invention regardless of whether co-action of elements is present. On the other hand, an inventive concept may reside in the selection of a part or parts of numerous old elements. If the selection is unusual and a hitherto unsolved problem is overcome, it answers the tests of the statute and, in the absence of other limiting features, will achieve invention. So here Bond did a novel thing in the science of culture of bacteria to inoculate leguminous plants. He knew what other scientists already had suggested that certain strains worked adversely and detrimentally to each other. Delving further, he learned for the first time that various strains of the genus are non-inhibitive of other strains and can be grouped, with an entirely healthy result. As a result of his teachings, scientists learned how to make a composite inoculant without disastrous conflict of one species of bacteria with another. True, the composite inoculant had been thought of and practiced to some extent, but just as truly it had not achieved approved recognition. Indeed, scientists thought that it was a dangerous practice, and Bond, for the first time, pointed out to the bacteriologist the fact of existing noninhibitive strains and instructed him that he should select such strains and make his composite inoculant of them. Thus he taught how to make a composite inoculant, successful, efficient and filling the need it was meant to fill. This is not so-called "aggregation." It is inventive conception.

We now approach the issue of infringement. The District Court found "that the product • • • 'Legume-Aid' is a composite inoculant for leguminous plants consisting of a plurality of selected cultures of bacteria, comprising at least two species or strains of bacteria of the genus Rhizobium, which do not affect one another in their respective abilities to fix nitrogen in association with leguminous plants for which each species or strain is specific," and that "the accused composite culture • • •

'Legume-Aid' constitutes an infringement of each and all of said Claims 1, 3, 4, 5, 6, 7, 8, 13 and 14 of said Bond patent in suit." Defendant insists that there is no evidence to sustain these findings.

In *Gary Theatre Co.* v. *Columbia Pictures Corp., et al.*, 120 F. 2d 890, 894 (CCA7) and *Webb* v. *Frisch, et al.*, 111 F. 2d 887, 888 (CCA7), this court has previously discussed sufficiently the application of Rule 52 (a) of Rules of Civil Procedure to findings of fact such as the court entered here. If there is substantial evidence to support the conclusion, though we may not agree with the trial court, we are not privileged to disturb the findings unless they are clearly erroneous. And due regard is to be given to the trial court's opportunity to observe the witnesses and to judge their credibility. *Apex Electrical Mfg. Co.* v. *Maytag Co., et al.*, 122 F. 2d 182, 187 (CCA7) and cases there cited.

The burden rests upon a plaintiff to show that the defendant has made, used, or sold the patented invention; if the testimony is of equal weight the defendant must prevail. If the plaintiff makes out a prima facie case, however, the defendant must overcome it by evidence. Robinson on Patents, Vol. 3, Section 1041. Walker on Patents, Section 532. "Proof of the infringements given, that the machines made and used by the defendants were substantially like the complainant's, was sufficient, if not rebutted." *Bennett* v. *Fowler*, 8 Wall. 445; *Spring and others* v. *Domestic Sewing Machine Co.*, 9 F. 509; *Pfeifer* v. *Brown & Co.*, 85 F. 780. In a copyright case, *Encyclopedia Britannica Co.* v. *American Newspaper Ass'n.*, 130 F. 460, the court said: "Substantial identity, or a striking resemblance between the work complained of and that for which protection is claimed, creates a presumption of unlawful copying, which must be overcome by the defendant." To the same effect is *General Drafting Co., Inc.* v. *Andrews et al.*, 37 F. 2d 54 (CCA2).

When the burden of proof is once fixed as to a particular issue, in a strict sense, the burden of producing a preponderance of evidence never shifts. But there may be and often is a shift in burden of producing rebuttal evidence to escape an adverse decision based on an uncontested prima facie case, for, once such a case is made out, the burden of proceeding with further evidence rests on the opposite party. *United States* v. *Denver & R. G. R. Co.*, 191 U. S. 84,

92, 48 L. Ed. 106, 109, 24 Sup. Ct. 33; *Harrison* v. *New York Life Ins. Co.*, 78 F. 2d 421; *Toledo Metal Wheel Co.* v. *Foyer*, 223 F. 350; Cyclopedia of Federal Procedure, 2d Ed., Vol. 7, Sec. 3174. And it has always been the law that where the knowledge and means of proof with respect to an issue are peculiarly within the power and control of one of the parties, the burden of proof is, to that extent, placed upon him, although it would otherwise rest upon his adversary. Cyclopedia of Federal Procedure, Sec. 3174; *Miller* v. *Lykes Bros. Ripley S. S. Co.*, 98 F. 2d 185, cert. denied 305 U. S. 641; *United States* v. *Denver & R. G. R. Co.*, 191 U. S. 84.

In this case, by its response to plaintiff's request for admissions, Federal Rule of Procedure 36, defendant admitted that the accused product is a combination or mixed culture containing two species or varieties of root nodule bacteria, *i. e.*, Rhizobium trifolii (the clover bacteria) and Rhizobium meliloti (the alfalfa bacteria); that these two species of root nodule bacteria are contained in a moist powder base including humus; and that the accused Legume-Aid "is as efficient in its ability to fix nitrogen" in either clover or alfalfa plants as a single clover culture containing the same strains of clover bacteria is on clover plants and as a single alfalfa culture containing the same strains of alfalfa bacteria is on alfalfa plants. Defendant represents on its label that the two species of bacteria are "highly efficient selected strains." Defendant admits also that clover and alfalfa bacteria are present in the accused Legume-Aid in the proportions of 9 to 10 billion alfalfa bacteria and 14 billion clover bacteria per package, approximately the proportions recommended by Bond. Upon this showing plaintiff submitted its claim of infringement.

We have seen that Claim 1 defines a composite inoculant for leguminous plants comprising a plurality of selected cultures of different species of Rhizobium bacteria. Defendant's product, under its admission, contains the same. The patentee specifies that the cultures shall be "substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plants for which they are specified" and the admission of defendant is that its composite of selected cultures of different species is as efficient to fix nitrogen in either clover or alfalfa as a single culture containing the same strains of clover bacteria is on clover plants and as single alfalfa species is on alfalfa plants.

Plaintiff's showing, therefore, made a prima facie case of infringement, and if the evidence stood alone, it would completely justify the finding of infringement made by the District Court. As the court commented in *Matheson* v. *Campbell*, 77 F. 280 at 284, plaintiff sustains the burden of proof, when it shows, as to infringement, that the alleged infringing product corresponds to the tests of identity. The burden is then upon the defendant to prove, if it can, that the product, though identical in composition, was not produced by the patented process. The further question presented then is as to whether defendant overcame this prima facie case, whether it has satisfactorily rebutted the presumption of infringement arising from plaintiff's evidence. That, obviously, is a question of fact, which, under the court's finding, has been decided adversely to defendant and which we are not justified in reversing unless we must say that, under the evidence presented, it is clearly erroneous.

We have examined the evidence and, though defendant insists that it does not make its composite product in accord with plaintiff's teaching and specifically denies that it makes any tests for the purpose of determining whether the different species are inhibitive or noninhibitive of each other, in view of all the evidence, we feel that we are not warranted in saying that the findings of fact are clearly erroneous. Defendant's assertion of noninfringement is based largely upon the testimony of Curie, an interested witness, in charge of manufacture of the accused product. He flatly denied that there are inhibitive bacterial strains. Other authorities disagree, and the trial court found his statement erroneous. Having denied that there are inhibitive strains, it followed, as Curie proceeded to say, that he never made any tests for inhibition or noninhibition. His testimony is not the most convincing. He admitted that he tested the mixed culture produced by defendant in an efficiency test as compared with a single culture. He admitted making tests with reference to legumes "to determine the efficiency of one strain of legume bacteria relative to others." He made "many nitrogen determinations of various legume plants." Whether he said he was testing for inhibition or testing for efficiency of composite product as compared with single products would seem to be of little importance. The question is, did he follow the teaching of Bond in determining what were efficient and nonefficient strains. He admitted that from time to time in the manufacturing

process; he discarded certain strains of bacteria as they proved to be no longer efficient or vigorous. He admitted making visual tests of the respective results of various cultures, contending that he never found undesirable or inefficient results exceeding from 10 to 20%, placing his mean at 15%. Obviously such a variation is of no small concern to the agriculturist who uses the product, if that variation is reflected in similar varying returns in crops. As a result of all this testimony, which we have read with care, we find ourselves still uncertain as to what Curie actually did and what the actual results of his tests were. At the most, we think we are not warranted in saying that the District Court clearly erred in concluding, after hearing Curie's testimony and observing him on the witness stand, that he had employed tests for efficiency of combined cultures in one composite product as compared with efficiency of single culture products and that these tests fulfilled the function of those prescribed by Bond. The evidence is not of such character that it is clear that the court was in error in its conclusion in this respect. We think the court was justified in finding that the patented process was substantially employed, especially when we remember that infringement is not negatived by mere avoidance of the best manner of practice or by failure to utilize the patent in its most advantageous form.

Remembering that identity of product raises a presumption of identity of process; that when a composition responds to the tests of identity prescribed by the patent, it is prima facie an infringement, as declared in *Matheson* v. *Campbell*, 77 F. 280; *Badische Anilin, etc. Fabrik* v. *Klipstein, etc., Co.*, 125 F. 543; *Holliday* v. *Schulze-Berge*, 78 F. 910, and that Curie's testimony in explanation is far from satisfactory rebuttal proof, we think that the District Court, who saw the witnesses and heard them testify, was not clearly in error in finding infringement.

The court dismissed the counterclaim of defendant for a declaratory judgment that all the claims of the Bond patent are invalid, being impelled to this action because it felt that, in view of its holding of invalidity of the claims in suit, there was no necessity of any adjudication upon the claims not relied upon by plaintiff. Claim 2, which was not presented in issue, is a product claim, similar to those in suit. Whether it is valid has not been adjudicated and is not before us. The other claims 9, 10, 11 and 12, are claims

for the method prescribed by Bond for the making of his composite inoculant. By the counterclaim defendant sought an adjudication that all claims are invalid or not infringed. Whether those claims are valid and whether defendant has infringed has never been decided because of the District Court's belief that it was unnecessary to make such decision. In a similar situation where the trial court held that, though by counterclaim defendant sought declaratory judgment, when the court found no infringement, there remained no justiciable controversy, the Supreme Court of the United States held in *Altvater* v. *Freeman*, 319 U. S. 359: "* * * To hold a patent valid if it is not infringed is to decide a hypothetical case. But the situation in the present case is quite different. We have here not only bill and answer but a counterclaim. Though the decision of noninfringement disposes of the bill and answer, it does not dispose of the counterclaim which raises the question of validity. *Sola Electric Co.* v. *Jefferson Electric Co.*, 317 U. S. 173, is authority for the proposition that the issue of validity may be raised by a counterclaim in an infringement suit. The requirements of case or controversy are of course no less strict under the Declaratory Judgments Act (38 Stat. 955, 28 U. S. C. Sec. 400) than in case of other suits. *United States* v. *West Virginia*, 295 U. S. 463, 475; *Ashwander* v. *Tennessee Valley Authority*, 297 U. S. 288, 325; *Aetna Life Ins. Co.* v. *Haworth*, 300 U. S. 227; *Maryland Casualty Co.* v. *Pacific Coal Co.*, 312 U. S. 270. But we are of the view that the issues raised by the present counterclaim were justiciable and that the controversy between the parties did not come to an end (*United States* v. *Alaska S. S. Co.*, 253 U. S. 113, 116) on the dismissal of the bill for noninfringement, since their dispute went beyond the single claim and the particular accused devices involved in that suit." *Schering Corporation* v. *Gilbert*, 153 F. 2d 428, 433; *Gebhard* v. *General Motors Sales Corporation*, 135 F. 2d 248, 249.

It has always been the desire of equity to dispose of all questions involved where it is at all possible to do so in order to prevent multiplicity of suits. So we think here that when plaintiff brought suit for infringement of certain claims and defendant counterclaimed seeking declaratory judgment upon all claims, the court, by judgment upon only the claims in suit, did not dispose of all issues in controversy between the parties. Defendant has a right to know

whether what it is doing violates any valid claim of plaintiff's patent. It has been confronted once with a suit for infringement and, though it does not manufacture, its principal, who defends, does manufacture and distribute, and, inasmuch as defendant itself distributes the inoculant, it has a right to know whether the product it does distribute infringes any valid claim. We think this is within the language of the Supreme Court as to what constitutes a justiciable controversy. The statute provides for declaratory judgment in the interest of prevention of multiplicity of litigation. We think the court below should have heard evidence upon and decided the counterclaim for a declaratory judgment.

The judgment is reversed in so far as it determined, (1), the claims in suit invalid, and, (2), dismissed the counterclaim, and is affirmed in so far as it disposed of all other issues.

And on the same day, to-wit: On the twelfth day of June, 1947, the following further proceedings were had and entered of record, to-wit:

Thursday, June 12, 1947.

Court met pursuant to adjournment.

Before:

Hon. Evan A. Evans, Circuit Judge.
Hon. J. Earl Major, Circuit Judge.
Hon. Walter C. Lindley, District Judge.

Kalo Inoculant Company, *Plaintiff-Appellant,*	Appeal from the District Court of the United States for the Southern District of Illinois, Southern Division.
9040 *vs.*	
Funk Brothers Seed Company, *Defendant-Appellee.*	

This cause came on to be heard on the transcript of the record from the District Court of the United States for the Southern District of Illinois, Southern Division, and was argued by counsel.

On consideration whereof, it is ordered and adjudged by this Court that the judgment of the said District Court in this cause appealed from be, and the same is hereby, reversed insofar as it determined, (1), the claims in suit invalid, and (2), dismissed the counterclaim. It is further ordered that the said Judgment be affirmed in so far as it disposed of all other issues.

It is further ordered that two-thirds (⅔) of the costs on these appeals be taxed against the Defendant, and one-third (⅓) against the Plaintiff.

Kalo Inoculant Company, *Plaintiff-Appellee,* vs. Funk Brothers Seed Company, *Defendant-Appellant.*	Appeal from the District Court of the United States for the Southern District of Illinois, Southern Division.
9041	

This cause came on to be heard on the transcript of the record from the District Court of the United States for the Southern District of Illinois, Southern Division, and was argued by counsel.

On consideration whereof, it is ordered and adjudged by this Court that the Judgment of the said District Court in this cause appealed from be, and the same is hereby, reversed insofar as it determined, (1), the claims in suit invalid, and (2), dismissed the counterclaim, It is further ordered that the said Judgment be affirmed in so far as it disposed of all other issues.

It is further ordered that two-thirds (⅔) of the costs on these appeals be taxed against the Defendant, and one-third (⅓) against the Plaintiff.

And afterwards, to-wit: On the twenty-seventh day of June, 1947, there was filed in the office of the Clerk of this Court a Motion for Stay of Mandate, which said Motion is in the words and figures following, to-wit:

IN THE UNITED STATES CIRCUIT COURT OF APPEALS

For the Seventh Circuit.

Kalo Inoculant Company, a corporation, *Plaintiff-Appellant, Cross-Appellee,* vs. Funk Brothers Seed Company, a corporation, *Defendant-Appellee, Cross-Appellant.*	Appeals Nos. 9040, 9041.

PETITION FOR STAY OF MANDATE.

Now comes the Defendant-Appellee, Funk Brothers Seed Company, and prays this Court for a stay of issuance of the Mandate in this cause (Appeals 9040 and 9041) for sixty (60) days pending application for a writ of certiorari to the Supreme Court of the United States.

Toulmin & Toulmin,
D. C. Staley,
Attorneys for Defendant-Appellee, Funk Brothers Seed Company.

B. A. Schroeder,
H. A. Toulmin, Jr.,
D. C. Staley,
Solicitors and Of Counsel for the Defendant.

Dayton, Ohio,
June 25, 1947.

A copy of this Petition is forwarded to Counsel for Plaintiff by First Class Mail.

Toulmin & Toulmin,
Attorneys for Defendant.

And on the same day, to-wit: On the twenty-seventh day of June, 1947, the following further proceedings were had and entered of record, to-wit:

Friday, June 27, 1947.

Court met pursuant to adjournment.

Before:

Hon. Evan A. Evans, Circuit Judge.

9040	Kalo Inoculant Company, *Plaintiff-Appellant*, *vs.* Funk Brothers Seed Company, *Defendant-Appellee.*	Appeals from the District Court of the United States for the Southern District of Illinois, Southern Division.
9041	Kalo Inoculant Company, *Plaintiff-Appellee*, *vs.* Funk Brothers Seed Company, *Defendant-Appellant.*	

On petition of counsel for Funk Brothers Seed Company, it is ordered that the issuance of the mandates of this Court in these appeals be, and the same is hereby, stayed for a period of sixty (60) days pending application to the Supreme Court of the United States for a writ of certiorari.

UNITED STATES CIRCUIT COURT OF APPEALS

For the Seventh Circuit.

I, Kenneth J. Carrick, Clerk of the United States Circuit Court of Appeals for the Seventh Circuit, do hereby certify that the foregoing printed pages contain a true copy of the papers filed and the proceedings had, concerning the hearing, the Opinion of the Court, Judgment, the Motion to Stay Mandate and the Order on the said Motion, as designated in the letter of counsel dated July 16, 1947, in:

Cause No. 9040-41.

Kalo Inoculant Company,
Plaintiff-Appellant,

vs.

Funk Brothers Seed Company,
Defendant-Appellee,

and

Kalo Inoculant Company,
Plaintiff-Appellee,

vs.

Funk Brothers Seed Company,
Defendant-Appellant,

as the same remains upon the files and records of the United States Circuit Court of Appeals for the Seventh Circuit.

In Testimony Whereof I hereunto subscribe my name and affix the seal of said United States Circuit Court of Appeals for the Seventh Circuit, at the City of Chicago, this 1st day of August, A. D. 1947.

(Seal)

Kenneth J. Carrick,
Clerk of the United States Circuit Court of Appeals for the Seventh Circuit.

SUPREME COURT OF THE UNITED STATES

ORDER ALLOWING CERTIORARI—Filed October 13, 1947.

The petition herein for a writ of certiorari to the United States Circuit Court of Appeals for the Seventh Circuit is granted. And it is further ordered that the duly certified copy of the transcript of the proceedings below which accompanied the petition shall be treated as though filed in response to such writ.

(3352)

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AUG 19 1947
CHARLES ELMORE CROPLEY
CLERK

In the Supreme Court of the United States

OCTOBER TERM, A. D. 1947.

No. 280

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

PETITION FOR WRIT OF CERTIORARI
To the United States Circuit Court of Appeals
For the Seventh Circuit
and
BRIEF IN SUPPORT OF PETITION.

H. A. TOULMIN, JR.,
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THE GATES LEGAL PUBLISHING CO., CLEVELAND, OHIO—MAIN 8647

INDEX.

PETITION FOR WRIT OF CERTIORARI 1

Summary Statement of the Matter Involved 2

Nature of the Subject Matter 2

Decision of the District Court 5

Decision of the Court of Appeals 6

Reasons for the Allowance of the Writ:

I. No patent can be sustained for monopoly of a law of nature of a product or composition of matter. To hold otherwise is in conflict with the decisions of this Court 6

II. An old product or products of nature in combination cannot be patented by a mere discovery of a new quality existent in nature from time immemorial: Under Sec. R. S. 4886 to be patentable, the combination must be new and useful and based upon a contribution to the public not existing in nature. To hold otherwise is in conflict with other Circuit Courts of Appeals 7

III. Diversity of opinion below: No other opportunity to present this case to this Court. The District Court and Court of Appeals are in conflict in this case on the issue of patentability of a law of nature: No opportunity for further conflict in other circuits will present itself 9

IV. Can the discoveries of the law of nature of natural products or composition of matter, without further contribution by the discoverer, be the subject of patent monopoly under the Statutes R. S. 4886 or do they belong to the public? 10

V. Public Importance 11

VI. A product claim that relies for its novelty upon a statement of function is invalid 11

Prayer 12

BRIEF IN SUPPORT OF PETITION FOR WRIT OF CERTIORARI 15

The Opinions of the Courts Below 15

Jurisdiction 15

Statement of the Case in Petition 16

Specification of Errors 16

Argument:

I. No patent can be sustained for monopoly of a law of nature of a product or composition of matter. To hold otherwise is in conflict with the decisions of this Court 17

II. An old product or products of nature in combination cannot be patented by a mere discovery of a new quality existent in nature from time immemorial: Under Sec. R. S. 4886 to be patentable, the combination must be new and useful and based upon a contribution to the public not existing in nature. To hold otherwise is in conflict with other Circuit Courts of Appeals 25

III. Diversity of Opinion Below: No other opportunity to present this case to this Court. The District Court and Court of Appeals are in conflict in this case on the issue of patentability of a law of nature. No opportunity for further conflict in other circuits will present itself 31

IV. Can the discoveries of the law of nature and of natural products or composition of matter, without further contribution by the discoverer, be the subject of patent monopoly under the Statutes R. S. 4886 or do they belong to the public? 34

V. Public Importance 38

VI. A product claim that relies for its novelty upon a statement of function is invalid 39

AUTHORITIES CITED.

Cases.

American Fruit Growers, Inc. v. Brogdex Co., 51 S. C. 328, 283 U. S. 1, 75 L. Ed. 801 ..... 7, 16, 36, 37

Barber-Coleman Co. v. A. G. Redmond Co. (CCA 6), 94 F. (2d) 717 9

Buckingham Products Co. v. McAleer Mfg. Co. (CCA 6), 108 F. (2d) 192 9

Burr v. Duryee, 1 Wall. 531, 570, 17 L. Ed. 650 ..... 7, 24

Cities Service Oil Co. v. Dunlap, 60 S. C. 201, 308 U. S. 208, 84 L. Ed. 196 7

City of Milwaukee v. Activated Sludge (CCA 7), 69 F. (2d) 577 9

Corona Cord Tire Co. v. Dovan Chemical Corporation, 48 S. C. 380, 276 U. S. 358, 72 L. Ed. 610 7

Cuno Engineering Corporation v. Automatic Devices Corporation, 62 S. C. 37, 314 U. S. 84, 86 L. Ed. 58 ..... 10, 22, 35

DeForest Radio Co. v. General Electric Co., 51 S. C. 563, 283 U. S. 664, 75 L. Ed. 1339 ..... 7, 16, 24

Dennis et al. v. Pitner et al. (CCA 7), 106 F. (2d) 142, 150, 151 ..... 26, 27, 28

Exhibit Supply Co. v. Ace Patents Corp., 62 S. C. 513, 315 U. S. 126, 86 L. Ed. 736 ..... 9, 16, 34

Flint v. G. R. Leonard & Co. (CCA 7), 27 F. (2d) 215 8

Guthrie v. Curlett (CCA 2), 10 F. (2d) 725 8

Halliburton Oil Well Cementing Co. v. Walker, 67 S. C. 6, 329 U. S. 1, 9, 91 L. Ed. 15 ..... 1, 11, 39

Hamilton Laboratories, Inc. v. Massengill (CCA 6), 111 F. (2d) 584 8

Hartranft v. Wiegmann, 7 S. C. 1240, 121 U. S. 609, 30 L. Ed. 1012 ..... 10, 37

Hazel-Atlas Glass Co. v. Hartford-Empire Co., 64 S. C. 997, 322 U. S. 238, 246, 88 L. Ed. 1250 38

Hotchkiss v. Greenwood, 11 How. 248 10

Katz v. Horni Signal Mfg. Co. (CCA 3), 145 F. (2d) 961 9

LeRoy et al. v. Tatham et al., 55 U. S. 156 (14 How. 156), 14 L. Ed. 367 ..... 7, 16, 21

Lincoln Engineering Co. of Illinois v. Stewart-Warner Corporation, 58 S. C. 662, 303 U. S. 545, 82 L. Ed. 1008 16

Mackay Radio & Telegraph Co. v. Radio Corporation of America, 59 S. C. 427, 306 U. S. 86, 94, 83 L. Ed. 506 ..... 7, 10, 35-36

Mercoid Corporation v. Mid-Continent Investment Co., 64 S. C. 268, 320 U. S. 661, 665, 88 L. Ed. 376 38

Morton v. New York Eye Infirmary (C. C. N. Y. 1863), Fed. Cas. 9865, 17 Fed. Cas. 881 ..... 8, 29

Morton Salt Co. v. G. S. Suppiger Co., 62 S. C. 402, 314 U. S. 488, 86 L. Ed. 363 38

Muncie Gear Co. v. Outboard Motor Co., 62 S. C. 865, 315 U. S. 759, 766, 86 L. Ed. 1171 ..... 9, 16, 34

Novocol Chemical Mfg. Co. v. Powers & Anderson Dental Co. (CCA 4), 128 F. (2d) 904 ..... 9, 30

O'Reilly v. Morse, 56 U. S. 62 (15 How. 62), 14 L. Ed. 601 ..... 7, 16, 22

A. & E. Pitman v. Pitman (CCA 1), 50 F. (2d) 744 ... 8-9

Precision Instrument Manufacturing Co. et al. v. Automotive Maintenance Machinery Company, 65 S. C. 993, 324 U. S. 806, 816, 89 L. Ed. 1381 ..... 11, 16, 38

Rubber-Tip Pencil Co. v. Howard, 87 U. S. 498 (20 Wall. 498), 22 L. Ed. 410 7

P. E. Sharpless Co. v. Crawford Farms, Inc. (CCA 2), 287 Fed. 655, 658 37

Schriber-Schroth Co. v. Cleveland Trust Company, 59 S. C. 8, 305 U. S. 47, 50, 83 L. Ed. 34; 304 U. S. 587, 58 S. C. 1052, 82 L. Ed. 1548 ..... 9, 16, 34

Smith v. Nichols, 88 U. S. 112 (21 Wall. 112, 119), 22 L. Ed. 566 22

Standard Brands, Inc. v. National Grain Yeast Corporation, 60 S. C. 27, 308 U. S. 34, 84 L. Ed. 17 24

The Telephone Cases, 8 S. C. 778, 126 U. S. 1, 31 L. Ed. 863 ..... 7, 16, 24

United States v. Masonite Corp., 62 S. C. 1070, 316 U. S. 265, 278, 86 L. Ed. 1461 38

Universal Winding Co. v. Foster Mach. Co. (CCA 1), 90 F. (2d) 472 8

Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation (CCA 9), 146 F. (2d) 941 ..... 25, 26, 28

Williams Mfg. Co. v. United Shoe Mfg. Corp., 62 S. C. 1179, 316 U. S. 364, 86 L. Ed. 1537 ..... 9, 16

Statutes.

R. S. 4886—35 U. S. C. A. Sec. 31 ... 10, 11, 25, 34; 35, 36, 38

R. S. 4888—35 U. S. C. A. Sec. 33 12

In the Supreme Court of the United States

OCTOBER TERM, A. D. 1947.

No. .....

FUNK BROTHERS SEED COMPANY,

Petitioner,

vs.

KALO INOCULANT COMPANY,

Respondent.

PETITION FOR A WRIT OF CERTIORARI
To the United States Circuit Court of Appeals For the Seventh Circuit.

To the Honorable The Chief Justice and Associate Justices of the Supreme Court of the United States:

Your petitioner, Funk Brothers Seed Company, respectfully prays that a writ of certiorari issue to the United States Circuit Court of Appeals for the Seventh Circuit to review the decree of that Court holding valid and infringed the claims in suit[1] of United States Letters Patent No. 2,200,532 to Varley Sherman Bond, which decree was entered on June 12, 1947. (R. 817.)

---

[1] The claims in suit are product claims 1, 3, 4, 5, 6, 7, 8, 13 and 14. Claim 4 is an example:

"An inoculant for leguminous plants comprising a plurality of selected mutually non-inhibitive strains of different species of bacteria of the genus Rhizobium, said strains being unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific."

Please note that the claims describe the product in terms of function. *Halliburton Oil Well Cementing Co. v. Walker*, 329 U. S. 1, 9.

SUMMARY STATEMENT OF THE MATTER INVOLVED.

The issue is whether you can secure a patent monopoly on a discovery of a law of nature and how it works, the patentee adding nothing to the operation of the law of nature either in mechanism or method. To permit such patenting is contrary to R. S. 4886.[1] There is conflict of opinion below on this issue. (R. 744), (R. 817.)

Nature of the Subject Matter.

The patentee claims as a patentable discovery that he can improve the old combination of different types of bacteria in a compost used to fix nitrogen in plants by his discovery that some bacteria do not adversely affect others according to the law of their nature. He selects, by old and conventional tests, those that do not so affect one another according to the law of their nature and discards those that do. He puts together those that do not affect one another in the old two bacteria combination.

This case is of great public and national interest as it monopolizes the present methods of raising clover, alfalfa, soy beans, etc., throughout the nation by the use of inoculating bacteria cultures to fix nitrogen in the plants—an old method of agriculture.

---

[1] R. S. 4886, 35 U. S. C. A. Sec. 31.

"Any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvements thereof, or who has invented or discovered and asexually reproduced any distinct and new variety of plant, other than a tuber-propagated plant, not known or used by others in this country, before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, or more than one year prior to his application, and not in public use or on sale in this country for more than one year prior to his application, unless the same is proved to have been abandoned, may, upon payment of the fees required by law, and other due proceeding had, obtain a patent therefor. R. S. § 4886; March 3, 1897, c. 391, § 1, 29 Stat. 692; May 23, 1930, c. 312, § 1, 46 Stat. 376; Aug. 5, 1939, c. 450, § 1, 53 Stat. 1212."

The Bond patent relates to a product known as an inoculant that may be applied to seeds of leguminous plants such as alfalfa, clover, soy beans, etc., before the seeds are placed in the ground. This inoculant for leguminous plants comprises a plurality of selected mutually non-inhibitive strains of different species of bacteria, the strains being unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which the strains are specific. As Bond says:

> "* * * said cultures being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific." (Claim 1, R. 779.)

The root nodule bacteria exist in nature as a plurality of individual species classified generally into six species of root nodule or legume bacteria which will infect six fairly well defined cross-inoculation groups of legumes. (R. 748, findings 9 and 10.)[1] Each species of root nodule bacteria includes innumerable individual strains of bacteria which vary in their efficiency, or ability to beneficially affect the plant to which they are specific by fixing nitrogen in the plant, "are widely spread in nature" (R. 773, column 1, line 45) and are natural inhabitants of the soil.

Bond's claimed discovery is that by conventional tests he has found that the nature of certain bacteria is that they do not affect each other while others do affect each other. He claims the combination of such selected bacteria which do not affect each other, but still operate according to the law of their nature.

[1]

Species	Cross-inoculation Group
Rhizobium trifolii	Red clover, crimson clover, mammoth clover, alsike clover
Rhizobium meliloti	Alfalfa, white and yellow sweet clovers
Rhizobium phaseoli	Garden beans
Rhizobium leguminosarum	Garden peas and vetch
Rhizobium lupini	Lupines
Rhizobium japonicum	Soy beans

The old steps in the preparation of the alleged "new" product of Bond are:

1. Bond obtains bacteria from nature by isolating a bacterium from a species of the legumes by well-known laboratory technique that was in existence before the advent of the Bond patent. (R. 775, column 1, lines 17-22; R. 116.)

2. After Bond isolates the bacterium he cultures the bacterium to cause it to reproduce and multiply many times, this also by laboratory technique known before the advent of the Bond patent (R. 115-116), and which, as admitted by Bond, does not in any way modify or change the natural characteristics of the bacteria from that as it existed in nature. (R. 116.)

3. Bond then performs standard routine tests known in the art before the Bond patent (R. 116), to determine the efficiency of the bacteria to fix nitrogen in the leguminous plant for which it is specific, as only efficient strains of bacteria are used by manufacturers of inoculants. (R. 120, 123.)

4. Bond follows the foregoing procedure with respect to several individual strains of bacteria for each species of the legumes, such as clover or alfalfa or soy beans or peas, and selects for further testing the strains of bacteria that have most efficiently fixed nitrogen in the legume for which the bacteria is specific.

5. To make the "Bond" composite inoculant, Bond performs additional tests under prior well-known standard technique wherein a species of the leguminous plants is inoculated with bacteria from a single culture and compared for nitrogen fixation efficiency with the same species of leguminous plant inoculated with an inoculant containing two or more independent species of bacteria (R. 776, column 2, line 63). If the bacteria in the inoculant that contains two independent species function in exactly the same way

they do in nature, having no effect upon one another in their ability to fix nitrogen, then this particular strain of bacteria is selected by Bond as an "alpha" strain for use in his composite inoculant. (R. 777, column 1, line 36.)

Bond admits of having not changed or modified the natural characteristics of the bacteria in any way. (R. 125.) He admits the base or carrier such as humus is not part of his invention and his method of putting the bacteria in the carrier is old. (R. 119.) In its essence Bond claims he discovered that certain strains of Rhizobium bacteria would not be affected by others in respect to their ability to fix nitrogen when placed together. The issue here is whether this discovery of a law of nature is patentable, without more.

Decision of the District Court

Respondent sued Petitioner for infringement of United States Letters Patent to Bond, No. 2,200,532, issued May 14, 1940. Respondent limited its charge of infringement to the product claims of the patent.

Petitioner, Defendant in the District Court, filed a Counterclaim asking for a Declaratory Judgment on the entire Bond patent for it contains claims directed to a product and claims directed to a method of making the product.

The District Court held invalid the product claims on the ground they did not involve "any new and useful art, machine, manufacture or composition of matter" (R. 744) under the patent statute, R. S. 4886, because they constituted an attempt to patent a law of nature.

The District Court dismissed the Petitioner's Counterclaim to have the method claims also declared invalid, these other claims being deemed not at issue.[1] (R. 744.)

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[1] Product claim 2 and method claims 9, 10, 11 and 12.

Decision of the Circuit Court of Appeals for the Seventh Circuit.

The Respondent appealed the decision of the District Court to the Circuit Court of Appeals for the Seventh Circuit (R. 755) and the Petitioner cross-appealed so much of the decision of the District Court as related to the dismissal of the Counterclaim and the holding of infringement by the product of the Petitioner. (R. 759.)

The Circuit Court of Appeals for the Seventh Circuit reversed the finding of the District Court concerning the validity of the claims in suit, holding them valid, sustained the District Court's holding of infringement of the claims in suit and reversed the District Court's dismissal of the Petitioner's counter-claim concerning the Declaratory Judgment on the remaining claims of the patent. (R. 834.)

This petition seeks a review of the decree reversing the District Court on its holding of invalidity of the product claims in suit. A decision in this Court on the fundamental question of patenting of a law of nature will dispose of the trial of the method claims as they hinge on the same question. Substantially the entire industry and the Petitioner are in or subject to the Seventh Circuit.

REASONS FOR THE ALLOWANCE OF THE WRIT.

Petitioner believes that writ of certiorari should be granted in this case for the following reasons, and accordingly the discretionary power of this Court is invoked.

I.

No Patent Can Be Sustained for Monopoly of a Law of Nature of a Product or Composition of Matter. To Hold Otherwise Is in Conflict with the Decisions of this Court.

The Circuit Court of Appeals for the Seventh Circuit in holding the Bond patent 2,200,532 valid, has rendered a decision in conflict with the principles of the decisions of

this Court such as in *LeRoy et al. v. Tatham et al.*, 55 U. S. 156, 14 How. 156, 14 L. Ed. 367; *O'Reilly v. Morse*, 15 How. 62, 120; *Rubber-Tip Pencil Co. v. Howard*, 20 Wall. 498, 22 L. Ed. 410; *Burr v. Duryee*, 1 Wall. 531, 17 L. Ed. 650; *The Telephone Cases*, 126 U. S. 1; *Corona Co. v. Dovan Corp.*, 276 U. S. 358; *American Fruit Growers, Inc. v. Brogdex Co.*, 283 U. S. 1; *Mackay Radio & Telegraph Co. v. Radio Corp. of America*, 306 U. S. 86, 94; *DeForest Radio Co. v. General Electric Co.*, 283 U. S. 664, which are to the effect that laws of nature and products of nature cannot be patented.

It is only when such laws of nature are utilized in new mechanisms or methods so that a contribution is made to the public by the inventor beyond a mere use of the laws of nature, that a patent can be lawfully granted.

The failure to follow established rules of this Court is reason for granting certiorari. *Cities Service v. Dunlap*, 308 U. S. 208.

II.

An Old Product or Products of Nature in Combination Cannot be Patented by a Mere Discovery of a New Quality Existent in Nature From Time Immemorial: Under Sec. R. S. 4886 to be Patentable, the Combination Must Be New and Useful and Based Upon a Contribution to the Public Not Existing in Nature. To Hold Otherwise Is in Conflict with Other Circuit Courts of Appeals.

The essence of the decision of the Circuit Court of Appeals for the Seventh Circuit was that "the discovery of a natural phenomenon, or of a quality or attribute of a well-known article and application of that quality in a successful combination which is of value to mankind, is entitled to patent protection." (R. 824.) It is therefore held that: "the sum total of all prior teaching is that mixed inoculants had been in existence before but they had been composed by hit-and-run methods without regard to whether

the various species included in the composite worked adversely to one another or inhibited one another in their respective growths. Some of them may have been successful because, by mere chance, only non-inhibitive species were included." (R. 824.) But Bond's alleged invention was simply in utilizing conventional tests to select only those that were not mutually inhibitive.[1]

In this position, we believe the Court is in grave error as it expands the monopoly of the patent laws to monopolize all fundamental research which should be preserved for the common stock of knowledge of all mankind so as to furnish the basis for proper monopoly of specific applications by mechanisms or methods of invention under the patent law. This decision is in conflict with the usual rule as stated in *Morton v. New York Eye Infirmary* (C. C. N. Y. 1863) Fed. Cas. 9865, 17 Fed. Cas. 881; *Universal Winding Co. v. Foster Mach. Co.* (CCA 1) 90 F. (2d) 472; *Hamilton Laboratories, Inc. v. Massengill* (CCA 6) 111 F. (2d) 584; *Flint v. G. R. Leonard & Co.* (CCA 7) 27 F. (2d) 215, citing *Corning v. Burden*, 15 How. 252, 14 L. Ed. 683; *Guthrie v. Curlett* (CCA 2) 10 F. (2d) 725; *A. & E. Pitman*

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[1] The following are quotations taken from the opinion of the Seventh Circuit Court of Appeals in this case:

"* * * what he discovered was that certain existing bacteria do not possess the mutually inhibitive characteristics which had previously prevented a successful commercial composite inoculant and that those uninhibitive species may be successfully combined. It was this contribution of non-inhibitive strains which successfully combine that brought about a new patentable composition. This was application of scientific knowledge to things existing in nature and the utilization of them in a desirable composite product which had not been previously achieved but which he did achieve and of which the public now has the benefit." (R. 823, 824.)

"As this court said, in *Dennis et al., v. Pitner et al., supra*, 'the discovery of a natural phenomenon, or of a quality or attribute of a well-known article and application of that quality in a successful combination which is of value to mankind, is entitled to patent protection.' We adhere to that pronouncement and we think Bond achieved that end." (R. 824.)

Mfg. Co. Inc. v. Pitman (CCA 1) 50 F. (2d) 744; *Barber-Coleman Co. v. A. G. Redmond Co.* (CCA 6) 94 F. (2d) 717; *City of Milwaukee v. Activated Sludge* (CCA 7) 69 F. (2d) 577; *Buckingham Products Co. v. McAleer Mfg. Co.* (CCA 6), 108 F. (2d) 192; *Novocol Chemical Mfg. Co. v. Powers & Anderson Dental Co.* (CCA 4) 128 F. (2d) 904; *Katz v. Horni Signal Mfg. Co.* (CCA 2) 145 F. (2d) 961, which are to the effect that the discovery of a natural phenomenon or of a quality or attribute of a well-known article and an application of that quality which is of value to mankind, without further contribution, is not patentable.

III.

Diversity of Opinion Below: No Other Opportunity to Present This Case to This Court. The District Court and Court of Appeals Are in Conflict in This Case on the Issue of Patentability of a Law of Nature. No Opportunity for Further Conflict in Other Circuits Will Present Itself for the Following Reasons:

The far-reaching public effect of the judgment of the Court of Appeals upon manufacturers of inoculants for leguminous plants, the doubtful validity of the patent in suit, and the improbability that any litigation will occur in another circuit whereby a conflict of decisions of different Courts of Appeals may arise, affects the entire agricultural industry and the public, in view of the concentration of the inoculant industry in the Seventh Circuit. This calls for the issuance of the writ according to the precedent established by this Court in *Schriber-Schroth v. Cleveland Trust Company*, 305 U. S. 47, 50, cer. gr. 304 U. S. 587, *Muncie Gear Co. v. Outboard Motor Company*, 315 U. S. 759, 766; *Exhibit Supply Company v. Ace Corporation*, 315 U. S. 126, 128, *Williams v. United Shoe*, 316 U. S. 364.

All of the major manufacturers of the inoculant industry are concentrated in the Seventh Circuit, with the exception of Agricultural Laboratories, Inc., located in the

Sixth Circuit but which is bound by any decision in this case through its admission, at the time of trial, of the defense of the instant case. By virtue of the judgment of which review is sought, Respondents have established the validity of the patent in suit in a circuit where substantially more than 90% of the inoculant industry is resident (supporting data cited *infra*, pages 31-33), unless by the granting of the writ here sought, this Court shall rule otherwise. Moreover, the owner of the patent resides in the Seventh Circuit, thus necessitating the bringing of any action for a Declaratory Judgment in that Circuit.

IV.

Can the Discoveries of the Law of Nature of Natural Products or Composition of Matter, Without Further Contribution by the Discoverer, be the Subject of Patent Monopoly Under the Statutes R. S. 4886 or Do They Belong to the Public?

The revolutionary decision of the Circuit Court of Appeals for the Seventh Circuit that a discovery of a natural phenomenon, or of a quality or attribute of a well-known article which is of value to mankind, is a patentable composition, raises a fundamental question of law applied to patents,—is a discovery of natural phenomena, or of a natural attribute of a product of nature, patentable under R. S. 4886 when the discoverer does nothing but use the natural phenomena or attribute in its natural form, without change, in the same old combination for the same purpose it performs in its natural habitat and in an old manner? We think not. *Hotchkiss v. Greenwood*, 11 How. 248; *Cuno Engineering Corp. v. Automatic Devices Corp.*, 314 U. S. 84; *Mackay Radio & Telegraph Co. v. Radio Corporation of America*, 306 U. S. 86; *Hartranft v. Wiegmann*, 121 U. S. 609.

V.

Public Importance.[1]

In view of the vast increase in fundamental research and the impetus in the use of biological inoculants necessary in the field of agricultural production upon which the life of this nation and other nations depends, the correctness and soundness of this decision and the assertion of patent rights under it are factors of great moment to the public, *Precision Instrument Mfg. Co. v. Automotive Mach. Co.*, 324 U. S. 806, and to the future course of the patent system. The decision of the Seventh Circuit in this case, unless reversed by this Court, will involve judicial controversy for years to come whether natural phenomena, or natural attributes or natural qualities or natural products, can be made subject to monopoly upon their mere discovery or use, regardless of the fact that the patent statute R. S. 4886, 35 U. S. C. A. Sec. 31, does not provide for patent protection on mere discoveries.

VI.

A Product Claim that Relies for its Novelty Upon a Statement of Function Is Invalid.

The foregoing rule was recently re-stated in *Halliburton Oil Well Cementing Co. v. Walker*, 329 U. S. 1, 9. This Court said:

> "The language of the claim thus describes this most crucial element in the 'new' combination in terms of what it will do rather than in terms of its own physical characteristics or its arrangement in the new combination apparatus. We have held that a claim with such a description of a product is invalid as a violation of Rev. Stat. 4888. *Holland Furniture Co. v. Per-*

[1] Many other industries than agriculture are affected by this decision as to bacteria and their natural functions, such as brewing industry, bread and yeast; solvents; medicinals and pharmaceuticals in the field of penicillin, streptomycin; lacquers and resins; sewage disposal and foods.

Kins-Glue Co., 277 U. S. 245, 256-57; *General Electric Co. v. Wabash Appliance Corp., supra*."

In this case the product claims in suit all depend upon functional statements of the action of the bacteria to not affect one another. They, are therefore, invalid under the familiar rule established by this Court. (R. S. 4888.)[1]

Prayer.

WHEREFORE, Your Petitioner respectfully prays that writ of certiorari be issued to the Circuit Court of Appeals for the Seventh Circuit to the end that this cause may be reviewed and determined by this Court in accordance with the principles of law heretofore announced by it; that the decree of the Circuit Court of Appeals for the Seventh Circuit be reversed as to the finding of validity of Bond patent 2,200,532, dated May 14, 1940; and that the Peti-

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[1] R. S. 4888, 35 U. S. C. A. Sec. 33.

"Before any inventor or discoverer shall receive a patent for his invention or discovery he shall make application therefor, in writing, to the Commissioner of Patents, and shall file in the Patent Office a written description of the same, and of the manner and process of making, constructing, compounding, and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound, and use the same; and in case of a machine, he shall explain the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions; and he shall particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery. The specification and claim shall be signed by the inventor. No plant patent shall be declared invalid on the ground of noncompliance with this section if the description is made as complete as is reasonably possible. R. S. 4888; March 3, 1915, c. 94, § 1, 38 Stat. 958; May 23, 1930, c. 312, § 2, 46 Stat. 376."

tioner be granted such other and further relief as may be deemed proper.

FUNK BROTHERS SEED COMPANY,
By H. A. TOULMIN, JR.,
Attorney for Petitioner.

H. A. TOULMIN, JR.,
D. C. STALEY,
Of Counsel.

In the Supreme Court of the United States

OCTOBER TERM, A. D. 1947.

No. . . . . .

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

BRIEF IN SUPPORT OF PETITION FOR WRIT OF CERTIORARI.

The Opinions of the Courts Below:

The memorandum of Holdings of the District Court is found on pages 744 and 745, Vol. 2 of the Record. The Findings of Fact and Conclusions of Law are found on pages 745 to 753, and the Judgment is found on page 754, Vol. 2 of the Record. The opinion of the Circuit Court of Appeals (Circuit Judges Evans and Major, and Lindley, District Judge, Judge Lindley writing the opinion) appears at pages 817 to 833, Vol. II of the Record. The opinion of the Circuit Court of Appeals is reported at 74 U. S. P. Q. 1.

Jurisdiction.

Petitioner would invoke the jurisdiction of this Court under Section 240(a) of the Judicial Code as amended by the Act of February 13, 1925, U. S. C. A. Tit. 28, Sec. 347, to review a judgment of the United States Circuit Court of Appeals for the Seventh Circuit dated June 12, 1947 (R. 834) in a suit for infringement and validity of the Bond patent 2,200,532 dated May 14, 1940.

The cases believed to sustain jurisdiction are:

LeRoy et al. v. Tatham et al., 55 U. S. 156;
Deforest Radio Co. v. G. E. Co., 283 U. S. 664;
O'Reilly v. Morse, 15 How. 62;
The Telephone Cases, 126 U. S. 1;
American Fruit Growers v. Brogdex, 283 U. S. 1;
Schriber-Schroth v. Cleveland Trust, 305 U. S. 47; 304 U. S. 587;
Exhibit Supply Co. v. Ace Corp., 315 U. S. 126;
Muncie Gear Co. v. Outboard Motor Co., 315 U. S. 759;
Williams Mfg. Co. v. United Shoe Mfg. Corp., 316 U. S. 364;
Precision Instrument Mfg. Co. v. Automotive Mch. Co., 324 U. S. 806;
Lincoln Engineering v. Stewart-Warner, 303 U. S. 545.

Statement of the Case in Petition.

The foregoing Petition contains a summary of the material facts necessary to an understanding of the reasons relied upon for the allowance of the writ as well as a statement of the questions involved in the case.

Specification of Errors.

The specification of errors herein relied upon are those reasons incorporated generally in the reasons set forth in the Petition as grounds for its allowance.

ARGUMENT.

I.

No Patent Can Be Sustained for Monopoly of a Law of Nature of a Product or Composition of Matter. To Hold Otherwise Is in Conflict with the Decision of This Court.

The product of the Bond Patent[1] is an inoculant containing two or more different species of bacteria for inoculating two or more kinds of leguminous plants in which it is claimed the two or more species of bacteria do not affect one another in their ability to fix nitrogen.

For many years, by some unexplained natural phenomena, these bacteria have infected the roots of plants, and have caused nodules to form on the roots, by reason of which, the plants draw more nitrogen out of the air into the plant than would normally be gathered by the plant without the bacterial inoculation.

In nature there are hundreds of strains of the different species of bacteria that daily perform this function of fixing nitrogen in the various leguminous plants: This has occurred from time immemorial. Man has no control over this process, even today; the bacteria acting according to their own law of nature. The patentee Bond does not claim that he has any control over these bacteria to regulate or change their natural functioning when he puts the two strains of bacteria in the old compost.

Of these hundreds of different strains of bacteria that can be found in nature, working according to their own law of nature, there are some strains which are weak in their ability to fix nitrogen and others which are strong in their

[1] Claim 4—is representative of the Bond Claims:

"An inoculant for leguminous plants comprising a plurality of selected mutually non-inhibitive strains of different species of bacteria of the genus Rhizobium, said strains being unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific."

ability to produce this function. They work according to their own law of nature and the patentee Bond does not make any claim that he changes the natural functioning of the bacteria by anything that he has discovered.

The many species of bacteria existing in nature in all parts of the world are not uniformly distributed over the land area, so that all of the bacteria may at all times be found in all land areas. Bacteriologists, many years ago, discovered that they could isolate these bacteria from nature and propagate them to increase their numbers and then place them in a suitable base or carrier medium* for distribution to the farmers to apply on their seed. Thus, a farmer whose soil did not have bacteria beneficial to the leguminous plants of a particular kind in his own land could purchase the cultivated bacteria, place them upon the seed, and thus carry the bacteria into the ground.

Bacteriologists have for many years produced inoculants in which either a single strain or a plurality of strains of bacteria were placed, that were beneficial to the leguminous plants. They have always endeavored to isolate different strains of bacteria from nature that would have the strongest possible natural characteristic for fixing nitrogen in the leguminous plants. This was a common procedure long before the advent of the Bond patent (PX-13, R-401), and is admitted by Bond. (R-120.)

Bacteriologists continually isolate bacteria from nature and test them according to conventional, well-known tests to determine the efficiency of the particular strain of bacteria to obtain more and more efficient strains for use in inoculants to give the farmer better and better results. (R-120.)

This process of selection of highly efficient strains of bacteria has been going on for many years so that all of the companies producing inoculants have stock strains of

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* medium—known as a compost.

the various bacteria that are highly efficient in their natural function of fixing nitrogen.

In the foregoing respect, the patentee Bond does not claim that he does anything different from that which has been done in the past with reference to the isolation selection and use of highly efficient strains of bacteria. (R-116.)[1]

The patentee Bond does not claim to be the inventor of composite or mixed inoculants. Mixed inoculants were known, sold and used long before his patent.[2]

He does not claim that he has anything new in the base or carrier, in his case humus, into which he places the bacteria. (R-119.)

He does not claim that he has any different method of propagating the bacteria to increase their numbers by which he effects any change in the natural characteristics of the bacteria. (R-116.)

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[1] Testimony of Bond

"Q. And this method of the separate cultivation of these strains that is set forth in your patent, as I understood you to say, that method was one that was well-known in the art at the time of your application for your patent, in 1938?

A. Yes, essentially. There are some slight variations that are described in the specifications that I don't recall seeing before.

Q. Those variations would not, in any way, affect the character of the bacteria?

A. No; that is correct.

Q. When you get through with your culture you have the same bacteria you got from nature, but you have more of it, is that correct?

A. That is true; that is correct.

Q. And that was well-known in the art among those skilled in the art, prior to the date of your application for your patent, or your claimed invention?

A. Yes, sir."

[2] Mixed inoculants were known in prior patents and publications DX-16, R-508; DX-17, R-564; DX-22, R-636; Patents to Earp-Thomas 865,965, R-780; 1,099,121, R-786; Manns, 1,320,701, R-804, and in commercial products DX-1, R-440; DX-4, R-442; DX-10, R-476; DX-11, R-478.

Bond does not claim that he places the bacteria into the humus base or carrier in any way different from the way in which the bacteria have been placed in the humus for many years before his patent. (R-119.)

He does not claim to have discovered any new bacteria that have different natural characteristics from the bacteria known in the art prior to his patent, nor does he claim to have discovered any species of bacteria that is more efficient than any bacteria known in the prior art, as found by the Circuit Court. (R. 819.)

We ask the question, then—what has Bond done that was not done or known before his patent?

It can be simply stated as this,—Bond claims to have discovered that of all of the bacteria that exist in nature of the genus Rhizobium, for use with leguminous plants, some of these bacteria will be affected by others when they are placed in association with one another while others will not be so affected:—an alleged discovery of the natural characteristics of bacteria when they are placed in association with one another.[1]

The issue here is—is such a discovery patentable when the patentee does nothing to change the natural characteristics of the bacteria, adds nothing to nor takes anything away from the bacteria, but merely uses the bacteria as selected by their own law of nature for use in an old and

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[1] The following quotation is taken from the decision of the Circuit Court:

"• • • what he discovered was that certain existing bacteria do not possess the mutually inhibitive characteristics which had previously prevented a successful commercial composite inoculant and that those uninhibitive species may be successfully combined. It was this contribution of noninhibitive strains which successfully combine that brought about a new patentable composition. This was application of scientific knowledge to things existing in nature and the utilization of them in a desirable composite product which had not been previously achieved but which he did achieve and of which the public now has the benefit." (R. 823, 824.)

well-known product to produce the same and well-known function.

Assuming, for the purpose of argument, that the patentee Bond did discover a previously unknown attribute of the bacteria for leguminous plants when they function according to their own law of nature, and assuming that the Circuit Court of Appeals for the Seventh Circuit correctly found "that what he discovered was that certain existing bacteria do not possess the mutually inhibitive characteristics," the question still is—is such a discovery patentable when the patentee does nothing more than use the result of the discovery in selecting the old combination of bacteria so that they do not fight one another?

To allow such a discovery to now become the subject of a patent monopoly, as held by the Circuit Court of Appeals,[1] is in direct conflict with the holding of this Court in *LeRoy et al. v. Tatham et al.*, 14 How. 156, 112:

> "A principle, in the abstract, is a fundamental truth; an original cause; a motive; these cannot be patented, as no one can claim in either of them an exclusive right • • • in all such cases, the processes used to extract, modify, and concentrate natural agencies, constitute the invention. The elements of the power exist; the **invention is not in discovering them, but in applying them to useful objects.**" (Emphasis ours.)

This Court in this same case, in further amplification of that principle, stated:

> "It is said, in the case of *The Household Company v. Neilson*, Webster's Patent Cases, 683: 'a patent will be good; though the subject of the patent consists in the discovery of a great, general and most comprehensive principle in science or law of nature, if that principle is by the specification applied to any special

[1] Quotation from decision of Circuit Court below:

"As this Court said, in *Dennis, et al., v. Pitner, et al., supra*, the discovery of a natural phenomenon, or of a quality or attribute of a well known article and application of that quality in a successful combination which is of value to mankind, is entitled to patent protection."

purpose, so as thereby to effectuate a practical result and benefit **not previously attained.**' " (p. 113.) (Emphasis ours.)

The essence of the reason for allowing a patent which incorporates a principle in science or a law of nature is that a practical result and benefit **not previously attained,** shall be obtained by a contribution by the inventor beyond the mere use of the law of nature.

Bond does not claim that he produces any different result than was produced by the prior mixed inoculants, he does not claim the result is produced in any different way nor that the result of inoculating leguminous plants satisfactorily was not obtained before his alleged invention. The most that Bond can claim is that his alleged invention permits the same result to be obtained that was obtained before his invention but with some degree of betterment. This does not rise to the dignity of invention. *Cuno Engineering Corp. v. Automatic Devices Corp.*, 314 U. S. 84, 91.

In *Smith v. Nichols*, 21 Wall. 112, 119, this Court said that "A mere carrying forward or new or more extended application of the original thought, a change only in form, proportions, or degree, the substitution of equivalents, doing substantially the same thing in the same way by substantially the same means with better results, **is not such invention as will sustain a patent.**" (Emphasis ours.)

In *O'Reilly v. Morse*, 15 How. 62, 120, this Court held that the broad claim 8 of Morse directed to the use of the motive power of electric current for making or printing intelligible characters at any distance, was **void because it was a claim "for an effect produced by the use of electromagnetism distinct from the process or machinery necessary to produce it."**

The patentee Bond here claims an effect that is distinct from the product itself, namely, that the bacteria when placed together in the composite culture shall not inhibit one another. Bond's inoculant does not incor-

porate the law of the natural functioning of the bacteria, or law of nature, but is merely an exemplification of the effect of the working of that law.

Similarly, a dog which belongs to a known species but which is bred according to a new biological law, does not embody that law. The dog is merely an exemplification of the law. But, looking at the dog, as a dog, we are not informed of the existence of any new biological law through the mere inspection of the dog.

So in this case, the Bond product will not, upon inspection, inform anyone of the existence of the law of nature by which the bacteria function. The product is a mere exemplification or use of the law of nature. It is not a new composition of matter produced by or incorporating the operation of the law of nature in that product.

Only if the object by itself in its proper operation reasonably informs a person possessing technical skill of the existence of a fact or truth previously discovered, shall that object be considered as embodying the discovery. A mere use of any composite inoculant, even though produced in exact accordance with the Bond patent, will not inform any skilled technician of the existence of the discovery of the natural functioning of the bacteria by which they are alleged to not inhibit one another. Bond himself admits in his patent that there is no way of determining the non-inhibitive characteristics of the bacteria except by testing it according to an old and well-known test procedure.[1]

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[1] Quotation from Bond Patent 2,200,532—page 5. (R-776-777.)

"No method has been observed whereby the alpha strains of the organisms may be differentiated from the mutually inhibitive group of Rhizobia other than by making actual nitrogen fixation tests by inoculating the various host plants with the proposed mixture of the Rhizobia." • • • "The method for carrying out tests for determining the amount of nitrogen fixed by leguminous plants in association with the various species of the Rhizobia are well known in the art and are given in detail by Fred and Waksman, *supra*, and Fred, Baldwin ar . McCoy, *supra*."

This Court has held that no inventor may compel independent experimentation by others to ascertain the bounds of his claims. *Standard Brands, Inc. v. National Grain Yeast Corporation*, 308 U. S. 34.

The holding of the Circuit Court is in direct conflict with the holding of this Court in *DeForest Radio Co. vs. General Electric Co.*, 283 U. S. 664 wherein this Court stated:

> "It is method and device which may be patented and not a scientific explanation of their operation. See *LeRoy v. Tatham*, 14 How. 156, 174-6."

In the *Telephone Cases*, 126 U. S. 1, 532, this Court stated:

> "In this art—or, what is the same thing under the patent law, this process, this way of transmitting speech—electricity, one of the forces of nature, is employed; but electricity, left to itself, will not do what is wanted. **The art consists in so controlling the force as to make it accomplish the purpose.**" (Emphasis ours.)

In *Burr v. Duryee*, 1 Wall. 531, 570, this Court stated:

> "We find here no authority to grant a patent for a 'principle' or a 'mode of operation' or an idea or any other abstraction."

The holding of the Circuit Court of Appeals[1] is not in harmony with the holdings of this Court for the decision of the Circuit Court of Appeals does not require a patentee to do anything but discover a natural phenomenon, a quality or an attribute of a well-known article which is of value to mankind to make it patentable.

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[1] See footnote No. 1, on page 21.

II.

An Old Product or Products of Nature in Combination Cannot be Patented by a Mere Discovery of a New Quality Existent in Nature from Time Immemorial: Under Sec. R. S. 4886 to be Patentable, the Combination Must be New and Useful and Based Upon a Contribution to the Public Not Existing in Nature. To Hold Otherwise is in Conflict with Other Circuit Courts of Appeals.

The decision of the Circuit Court of Appeals for the Seventh Circuit is in conflict not only with the decisions of this Court but it is also in conflict with the principles of the decisions of other Courts of Appeals of other circuits.

The outstanding example of the conflict that currently exists is the conflict with the decision rendered in *Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation* (CCA 9) 146 F. (2d) 941.

In this case action was brought by Wisconsin Alumni Research Foundation against Vitamin Technologists, Inc., for infringement of three Steenbock patents relating to a process of producing vitamin "D" by activating ergosterol and yeast with ultra-violet rays produced by a mercury vapor lamp. The Court stated in its decision:

> "We refuse to entertain the absurd proposition that because the farmer and copra grower did not know the photo chemical process involved in their immemorial practice, they may be enjoined as infringers."
>
> "Assuming that Dr. Steenbock discovered, as he claims, that the sun's rays coming from millions of miles away could irradiate foods with vitamin D and that this was the reason, unknown to them, why farmers and coconut growers regarded their sun-cured hays and sun-dried copra were good foods, such a discovery does not entitle him to a patent on their processes." (p. 948.)

Further, in a concurring opinion, Judge Healy stated:

> "I assume, therefore, that Steenbock discovered and sufficiently disclosed in his claims the most effective time period of exposure. Nevertheless such a

discovery would not amount to a patentable invention. It would amount to no more than the ascertainment of a naked fact or principle in nature existing independently of the efforts of the discoverer. Cf. *O'Reilly v. Morse*, 15 How. 62, 14 L. Ed. 601; *Tilghman v. Proctor*, 102 U. S. 707, 722-729, 26 L. Ed. 279." (p. 954.)

The decision of the Circuit Court of Appeals for the Seventh Circuit in the case here is stated to be in accord with the decision of the Court of Appeals for the Seventh Circuit in *Dennis et al. v. Pitner et al.*, 106 F. (2d) 142, the Court in effect quoting from its decision in *Dennis et al. v. Pitner et al.*,[1] and adhering to that pronouncement[2] when holding the Bond patent valid.

The Hon. Evans A. Evans, Judge, Circuit Court of Appeals for the Seventh Circuit, wrote the decision in

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[1] Decision of CCA-7 in *Dennis, et al., v. Pitner, et al.*

"We must reject defendants' first defense, namely, that the cube roots utilized as an insecticide may not involve patentable invention under any circumstances, because such discovery is merely a revelation of an existing law of nature. We believe the importance of this conclusion justifies a somewhat extended discussion.

"(1) We believe it to be a sound pronouncement to say:—The discovery of a natural phenomenon, or of a quality or attribute of a well-known article, which discovery is of value to mankind, may be entitled to patent protection. The objection frequently offered to the patentability of such a discovery is that it is a law of nature or a principle of nature and for that reason not patentable. Section 31, Title 35, U.S.C.A., authorizes the issuance of a patent to 'Any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvements thereof * * * not known or used by others in this country, before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof * * *.'"

[2] Quotation from Decision of CCA-7 in this case:

"As this Court said, in *Dennis, et al., v. Pitner, et al., supra*, the discovery of a natural phenomenon, or of a quality or attribute of a well known article and application of that quality in a successful combination which is of value to mankind, is entitled to patent protection. We adhere to that pronouncement and we think Bond achieved that end."

the case of *Dennis v. Pitner*, 106 F. (2d) 142 at which time the pronouncement of the Court that a discovery of the quality or attribute of a well-known article and application of that quality in a successful combination which is of value to mankind, is entitled to patent protection, was first made.

However, the patents involved were held invalid on the ground of prior use. Thus this decision did not present an opportunity for it to be brought to the attention of this Court.

The public importance of the question that is at issue here and the conflict of this question with the decisions of this Court and all other Circuit Courts of Appeals was recognized by Judge Evans in a speech delivered to the Pittsburgh Patent Law Association, December 13, 1944,[1] at which time Judge Evans announced that in the case of *Dennis et al. v. Pitner et al.*, 106 F. (2d) 142, the Court reached a conclusion opposed to that announced in the *Vitamin* case.[2] With the Court of Appeals now holding that the present case is in harmony with *Dennis v. Pitner*,

[1] Published in the Journal of the Patent Office Society, May, 1945, Vol. 27, No. 5.

[2] The following quotation is taken from Judge Evans' speech:

"*Laws of Nature.* I now turn to the second matter wherein the patent law might be improved. A decision has recently been announced and quite as suddenly withdrawn,—*Vitamin Technologists v. Wisconsin Foundation*, which brings the question to a prominence that tolerates no avoidance. I refer to the ruling, quite old in text and in the speech of thoughtless patent lawyers, but only when hard put in their efforts to defeat a notable discovery, which denied patents to patentable discoveries because, so it is said, the discovery was merely a new application of an old law of nature. In the case of *Dennis v. Pitner*, 106 F. (2d) 142, the court of which I am a member, reached the conclusion opposite to that announced in the *Vitamin* case. In our case the majority opinion tried to lay down the rule which would grant protection to that vast number of researchers who work in the field of science, particularly chemistry, and are constantly contributing to the benefit of man by discoveries which have been outstanding, and yet under the rule announced in the Ninth Circuit, would be condemned as unpatentable because they are but the adaptation of a law of nature."

it is clear that this case is in conflict with *Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation.*

The Court of Appeals for the Seventh Circuit and of the Ninth Circuit are, therefore, in direct conflict on the question of the patentability of a discovery of a law of nature.

We believe the decision in the *Vitamin Technologists* case to be sound and in accord with the decisions of this Court and with our patent statutes as enacted by Congress by which patent protection has been refused merely for discoveries of the laws of nature or of physical phenomena or of particular attributes or qualities of well-known devices. (R. S. 4886.) What Congress has not done by legislation, the Circuit Court of Appeals for the Seventh Circuit now attempts to do by adjudication. Even the Honorable Judge Evans recognized the fact that Congress has not legislated authority to the Patent Office to grant patents to those who make outstanding discoveries of immeasurable value to society but which, for the statute, would be patentable.*

One can well imagine the confusion that will exist in our judicial system for years to come if this Court does not now render its decision on the correctness either of the *Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation* case, or of *Dennis et al. v. Pitner et al.*, and this case.

If the position of the Circuit Court of Appeals for the Seventh Circuit is allowed to stand, the patent laws will be expanded through judicial pronouncement to monopolize all fundamental research which should be preserved for

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* The following quotation is from Judge Evans' speech before the Pittsburgh Patent Law Association, December 13, 1944.

"Congress should be asked to meet these holdings by authorizing the grant of a patent to two or more who make an outstanding discovery of immeasurable value to society—under circumstances which, but for the said rule, would be patentable. Second, the discovery of a new use of an old principle, or law of nature, should be entitled to patent protection as fully as if it were a new combination of old elements."

the common stock of knowledge of all mankind and it will not be restricted to proper monopoly of specific applications by mechanisms or methods as required under the patent statute R. S. 4886.

Further, the decision of the Circuit Court of Appeals for the Seventh Circuit is in conflict with the case of *Morton v. New York Eye Infirmary* (C. C. N. Y. 1863), CCA 2, Fed. Case 9865, 17 Fed. Cas. 881. In this case Morton had discovered the anaesthetic effect of ether when applied to the human body. The Court very ably stated:

> "In its naked ordinary sense, a discovery is not patentable. A discovery of a new principle, force, or law operating, or which can be made to operate, on matter, will not entitle the discoverer to a patent. It is only where the explorer has gone beyond the mere domain of discovery, and has laid hold of the new principle, force, or law, and connected it with some particular medium or mechanical contrivance by which, or through which, it acts on the material world, that he can secure the exclusive control of it under the patent laws. He then controls his discovery through the means by which he has brought it into practical action, or their equivalent, and only through them. It is then an invention, although it embraces a discovery."

Imagine the effect on human welfare and the restriction that would have been placed on the advancement of medical science if the discovery of the anaesthetic effect of ether when applied to the human body, would have been declared the subject of a valid patent. We submit the same far-reaching effect is now at stake in this case for in the last few years it is the common practice for farmers to seed their fields with a mixed seeding of clover and alfalfa.

If this alleged discovery of Bond is allowed to remain as a valid patent, it will stop all further progress in the bacteriological art as applied to the Rhizobium bacteria for use in agriculture. No manufacturer could put himself in the position of placing two or more species of bacteria together in a common carrier to inoculate any mixed seed-

ing of any kind for fear of infringing the Bond patent. This, regardless of the fact that the species of bacteria the manufacturer placed together had been known to him and used by him with highly successful results for many years before the advent of the Bond patent, and regardless of the method by which he put these bacteria together.

Bond endeavors to monopolize an entire industry by a mere discovery of the law of the nature of the functioning of bacteria over which he has no control.

The decision of the Circuit Court is in conflict with *Novocol Chemical Manufacturing Co. v. Powers & Anderson Dental Company* (CCA 4), 128 F. (2d) 904, 907:

> "There was no invention in conducting routine tests to prove or disprove the existence of a physical fact. Patents may be issued for arts, machines, manufactures and compositions of matter, 35 U. S. C. A. § 31. But the laws of nature and their workings are not the subject of invention by man. He may discover them and bring them to the knowledge of the world but he cannot patent that discovery; he can obtain a patent only when he has invented an art or a machine whereby to utilize his discovery. *O'Reilly v. Morse* (involving invention of the telegraph) 15 How. 62, 112, 14 L. Ed. 601; *Walker on Patents*, 6th Ed., Sect. 18."

and is further in conflict with decisions of the First, Third and Sixth Circuits in cases cited in the Petition. (See pages 8-9.)

III.

Diversity of Opinion Below: No Other Opportunity to Present This Case to this Court. The District Court and Court of Appeals Are in Conflict in this Case on the Issue of Patentability of a Law of Nature. No Opportunity for Further Conflict in Other Circuits Will Present Itself for the Following Reasons:

The far-reaching public effect of the judgment of the Circuit Court of Appeals for the Seventh Circuit upon manufacturers of inoculants for leguminous plants can readily be appreciated in view of the concentration of all of the major manufacturers of inoculants in the Seventh Circuit.

This is shown by the publication of the United States Department of Agriculture, Circular 724, dated May, 1945, which is its latest circulated report on its annual tests of the products of all manufacturers producing inoculants. The present report covers the period July 1, 1943 to June 30, 1944, during which a total of 668 samples bearing 38 different trade names were collected in 33 States. These samples are the products of 10 manufacturers, a list of whom, together with the trade names used, is given below.[1]

Agricultural Laboratories, Inc., is the only major manufacturer located outside the Seventh Circuit However, this company is bound by the decision in this case since it is the manufacturer of the alleged infringing prod-

[1]

Mfrs. in Seventh Circuit	*Mfrs. beyond Seventh Circuit*
HANSEN INOCULATOR CO.	NELSON LABORATORIES,
Urbana, Ill.	Stockton, Calif.
Products Mfr'd.	*Products Mfr'd.*
Hansen's Humus Inoculator	Cal-Rhiz.
Co-op Humus Inoculator	EARP-THOMAS LABORATORIES, Inc.
Eastern States Legume Inoculant	Bloomfield, N. J.
Hansen's Inoculator	*Products Mfr'd.*
Kelly's Humus Inoculator	Farmogerm
	Humogerm

(Continued on following page)

uct and admitted full defense of the suit at the trial before the District Court.*

The companies that are beyond the Seventh Circuit, with the exception of Agricultural Laboratories, Inc., are small companies doing a local business. Those companies in the Seventh Circuit together with Agricultural Labora-

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* The defense of the suit by Agricultural Laboratories, Inc., was admitted by Counsel for the Defendant in the opening statement before the District Court as follows:

"The Agricultural Laboratories, Inc., is not a Defendant of record, although we have in Answer to the Interrogatories frankly admitted that we are the manufacturer of the accused product and we have taken over the management and control of this defense and are for all practical purposes the real Defendant in this action."

(*Continued from preceding page*)

THE LEGUMOGEN LABORATORIES, Inc.
Delphi, Ind.
Products Mfr'd.
Legumogen

THE NITRAGIN CO., Inc.
Milwaukee, Wisc.
Products Mfr'd.
Nitragin
(all products of this company are sold under one name)

THE ALBERT DICKINSON CO.
Chicago, Ill.
Products Mfr'd.
Nod-O-Gen Pretested Inoculator
Cofer's Hitest Inoculator
Gold Medal Inoculator
Hoffman's Inoculator
May-Bell Inoculator
M Inoculator
Ohio Farmers Seed Inoculation
Simplex 2 in 1 Inoculator
Trinity Brand Inoculator
Wood's Seed Inoculation

AGRICULTURAL LABORATORIES, Inc.
Columbus, Ohio.
Products Mfr'd.
Legume-Aid
G.L.F. Legume Inoculant
Sacco Legume Inoculant
Unico Legume Inoculant

STRASBURGER & SIEGEL
Baltimore, Md.
Products Mfr'd.
Superyield Culture

(*Continued on following page*)

tories, Inc. do well over 90% of the business in the inoculant industry according to well-informed reports.

If the judgment of the Circuit Court of Appeals for the Seventh Circuit be permitted to stand, and become final, Respondents will have it within their power either to stop or to levy a heavy tribute upon the production of the inoculant industry to the detriment not only of the Petitioners, but of the public at large.

Further, in view of the residence of the owners of the patent in the Seventh Circuit, no test of the validity of the patent could be made by suit under the Declaratory Judgment Act except in the Seventh Circuit.

There is, therefore, no real likelihood that any occasion will arise which would present a conflict of decisions of Courts of Appeals of different Circuits on the same claims of the Bond patent to afford a ground for the exercise of

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(*Continued from preceding page*)

KALO INOCULANT CO.,
Quincy, Ill.
Products Mfr'd.
Uni-Culture No. 2
American Tubercle Germ
Berry's Superior Nodule Germ
Blue Ribbon Inoculation
Blue Seal Grow Crop Inoculant
Corneli Keystone Inoculation
Farm Master Nitrogen-Fixing Inoculant
Kalo Inoculation
Perfection Brand Legume Inoculant
Southern States Quality Inoculation
Uni-Culture No. 3

THE URBANA LABORATORIES,
Urbana, Ill.
Products Mfr'd.
Urbana Culture
Urbana Humus Inoculator

the jurisdiction of this Court. Unless the Petition now presented be granted under the precedent established by this Court in *Schriber-Schroth v. Cleveland Trust Co.*, 305 U. S. 47, 50, cer. gr. 304 U. S. 587; *Exhibit Supply Co. v. Ace Corp.*, 315 U. S. 126; *Muncie Gear Co. v. Outboard Motor Co.*, 315 U. S. 759, an unconscionable domination of a large part of the inoculant industry by a patent of extremely doubtful validity, will stand established.

IV.

Can the Discoveries of the Laws of Nature and of Natural Products, Without Further Contribution by the Discoverer be the Subject of Patent Monopoly Under the Patent Statute R. S. 4886, or Do They Belong to the Public?

The revolutionary decision of the Circuit Court of Appeals for the Seventh Circuit raises a fundamental question of the law of nature as it applies to a proper interpretation of the patent Statute R. S. 4886,[1] when the discoverer does nothing but use the natural phenomenon or attribute in its natural form, without change, for the same purpose it performs in its natural habitat, in an old way.

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[1] R.S. 4886, 35 U.S.C.A. Sect. 31.

"Any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvements thereof, or who has invented or discovered and asexually reproduced any distinct and new variety of plant, other than a tuber-propagated plant not known or used by others in this country, before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, or more than one year prior to his application, and not in public use or on sale in this country for more than one year prior to his application, unless the same is proved to have been abandoned, may, upon payment of the fees required by law, and other due proceeding had, obtain a patent therefor. R.S. §4886; March 3, 1897, c. 391, §1, 29 Stat. 692; May 23, 1930, c. 312, §1, 46 Stat. 376; Aug. 5, 1939, c. 450, §1, 53 Stat. 1212."

This decision establishes a precedent whereby anyone may take an article or a product that is well known, is being manufactured, sold and used, and may, upon his discovery that this old and well-known article possesses an attribute or a quality that had hitherto been unknown, obtain a patent and thereby create a monopoly on an old product even though it had been made, sold and used for years prior to the discovery of the unknown attribute or quality.

Is the old combining of two natural products continuing to function in the same way which are so selected as to not affect one another, a patentable composition of matter? We think not.

> "Since *Hotchkiss v. Greenwood*, 11 How. 248, 267, decided in 1851, it has been recognized that if an improvement is to obtain the privileged position of a patent more ingenuity must be involved than the work of a mechanic skilled in the art." *Cuno Engineering Corp. v. Automatic Devices Corp.*, 314 U. S. 84, 90.

The decision of the Circuit Court of Appeals does not take into account the fact that the Statute R. S. 4886 requires that an invention or discovery shall be "new" as well as "useful." It makes no difference how useful a device or a product may be, or how revolutionary its character may be, **if it is not new** as well as useful, it fails to meet with the patent Statute. This Court has said in *Cuno Engineering Corp. v. Automatic Devices Corp.*, 314 U. S. 84, 90, "Under the Statute (35 U. S. C. § 31; R. S. 4886) the device must not only be 'new and useful,' it must also be an 'invention' or 'discovery.' *Thompson v. Boisselier*, 114 U. S. 1, 11." The reverse of the situation is also true, i.e., to make a device patentable, it must not only be an invention or a discovery, but must also be "new" and useful. That which has existed as a fundamental law of nature is not "new."

The pronouncement of this Court in *Mackay Radio & Telegraph Co. v. Radio Corporation of America*, 306 U. S.

86, 94, which the Circuit Court of Appeals for the Seventh Circuit says is in accord with its holding, does not support the Circuit Court. This Court said:

> "While a scientific truth, or the mathematical expression of it, is not patentable invention, a **novel** and useful **structure** created with the aid of knowledge of scientific truth may be." (Emphasis ours.)

It will be noted here that this Court stated that to be patentable there must be "novel structure" created by the patentee. The Circuit Court in the vital statement of its decision[1] does not use any language which could be interpreted as meaning "new" or "novel" within the meaning of the statute or within the meaning of the decision of this Court.

The decision of the Circuit Court of Appeals in reversing the decision of the District Court[2] is in conflict with the decision of this Court in *American Fruit Growers, Inc. v. Brogdex*, 283 U. S. 1 and with R. S. 4886, 35 U. S. C. A. Sec. 31. For a patent to issue it must be for an "art, machine, manufacture or composition of matter." Admittedly, the product claims in suit are neither an art or a machine. They

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[1] Quotation from decision of CCA-7:

"* * * the discovery of a natural phenomenon, or of a quality or attribute of a well known article and application of that quality in a successful combination which is of value to mankind, is entitled to patent protection."

[2] Decision of District Court re Bond Patent said:

"With some reluctance I find that the claims in suit of the Bond patent are invalid under our patent statute, because they do not involve the invention or discovery of 'any new and useful art, machine, manufacture, or composition of matter.' I say, 'with reluctance,' because I was impressed at the trial with the very great diligence and ingenuity of Mr. Bond and with the results he obtained. His work is not to be minimized. Notwithstanding the value of his work, however, I feel quite positive that it cannot be classified under any of the subjects covered by the Act and must, therefore, be held nonpatentable. I deem this holding to be in harmony with the weight of authority and not in conflict with the decision in *Dennis v. Pitner*."

are not a manufacture within the terms of the *American Fruit Growers v. Brogdex* case for as this Court stated there:

> "'Manufacture,' as well defined by the Century Dictionary, is 'the production of articles for use from raw or prepared materials by giving to these materials new forms, qualities, properties, or combinations, whether by hand labor or by machinery.' Also 'anything made for use from raw or prepared materials'." (p. 11)

And the Court quoting from *Hartranft v. Wiegmann*, 121 U. S. 609, stated:

> 'There must be transformation; a new and different article must emerge 'having a distinctive name, character or use'." (p. 13)

The patentee Bond does not claim a new and different article or a transformation of an article or a transformation of substance or a new combination of elements. All he claims is an old combination of old elements in the same arrangement that they have always been used and for the same old purpose.

Neither can the product of the claims in suit be said to be a true composition of matter for here the individual elements lose their identity and the composition takes on qualities that neither of the individual elements possessed. *P. E. Sharpless Co. v. Crawford Farms, Inc.*, (CCA 2) 287 F. 655, 658. If the elements of the composition of matter do not lose their identity, or if results are not obtained by the combination of elements that are not obtained by either of the elements used alone, then we have only a mixture of independent substances.

[illegible] then, the Circuit Court of Appeals is in error [illegible] the holding of the District Court.

V.

Public Importance.

In view of the vast increase in fundamental research and the impetus in the use of bacteria in medicines and industrial products as well as in the field of agriculture upon which the life of this nation and other nations depend, the correctness and soundness of this decision of the Circuit Court of Appeals for the Seventh Circuit and the assertion of patent rights under it is of great moment to the public. Unless the fundamental question* raised here is now settled by this Court this decision will cause judicial controversy for years to come regardless of the fact that the Patent Statute R. S. 4886 does not provide for patent protection on mere discoveries.

The possession and assertion of patent rights are "issues of great moment to the public." *Hazel-Atlas Glass Co. v. Hartford-Empire Co.*, 322 U. S. 238, 246. See also *Mercoid Corp. v. Mid-Continent Investment Co.*, 320 U. S. 661, 665; *Morton Salt Co. v. Suppiger Co.; United States v. Masonite Corp.*, 316 U. S. 265, 278.

A patent by its very nature is affected with a public interest. The far-reaching social and economic consequences of a patent, therefore, give the public a paramount interest in seeing that patent monopolies spring from backgrounds free from fraud or other inequitable conduct **and that such monopolies are kept within their legitimate scope.** *Precision Instrument Manufacturing Co. et al. v. Automotive Maintenance Machinery Co.*, 324 U. S. 806, 816.

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* See Footnote No. 1, page 36.

VI.

A Product Claim That Relies For Its Novelty Upon a Statement of Function is Invalid.

The Bond claims describe the most crucial element of his alleged invention in terms of what the bacteria will not do, rather than in terms of their own physical characteristics. In the claims, the bacteria are said to be "selected cultures of different species of bacteria of the genus Rhizobium * * * said cultures being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific." (Claim 1, R-779).

In the case of *Halliburton Oil Well Cementing Co. v. Walker*, 329 U. S. 1, 9, this Court said:

> "The language of the claim thus describes this most crucial element in the new combination in terms of what it will do rather than in terms of its own physical characteristics or its arrangement in the new combination apparatus. We have held that a claim with such a description of a product is invalid as a violation of Rev. Stat. 4888; *Holland Furniture Co. v. Perkins Glue Co.*, 277 U. S. 245, 256-57; *General Electric Co. v. Wabash Appliance Corporation, supra.*"

The fact that this patent is on the verge of monopolizing and controlling the complete inoculant industry for years to come in view of the universal practice of farmers to use mixed seedings of clover and alfalfa requiring the use of mixed inoculants, makes it essential in the public interest that this vast monopoly be controlled strictly in accordance with the patent statute and within the principles of law announced by this Court.

We earnestly submit that this Court should order up this case.

Respectfully submitted,

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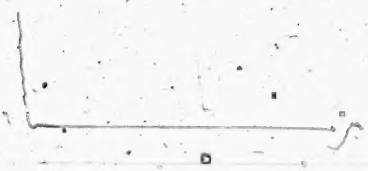

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In the Supreme Court of the United States

OCTOBER TERM, A. D. 1947.

No. 280.

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

REPLY BRIEF FOR PETITIONER.

H. A. TOULMIN, JR.,
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Of Counsel.

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INDEX.

The Issue Presented 1

Respondent's "Restatement of the Facts" States a Problem that Was Not in Existence 3

The Seed Inoculant Industry Is Concentrated in or Subject to the Seventh Circuit 5

The Opinion of the Court Below Is in Conflict with the Decisions of the Circuit Court of Appeals for the Ninth Circuit 6

The Bond Product Is Not a Patentable Composition of Matter Under R. S. 4886 8

The Claims of the Bond Patent Are Invalid Within the Meaning of *Halliburton Oil Well Cementing Co. v. Walker*, 329 U. S. 1 9

APPENDIX.

Affidavit of Miles M. Elmers 11

AUTHORITIES CITED.

Cases.

Boston Pencil Pointer Co. v. Automatic Pencil Sharpener Co. (C. C. A. 2), 276 Fed. 910 3

Collar Co. v. Van Dusen, 23 Wall. (90 U. S.) 530, 23 L. Ed. 128 2

Davis Co. v. New Departure Co., 217 F. 775 9

Dennis et al. v. Pitner et al. (C. C. A. 7), 106 F. (2d) 142 8

Dunbar v. Myers, 94 U. S. 187, 24 L. Ed. 34 3

General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 58 S. Ct. 899, 82 L. Ed. 1402 ..... 9, 10

Glue Company v. Upton, 6 Official Gazette 840 2

Gyrex Corp. v. Dilex Institute, 85 F. (2d) 103 9

Halliburton Oil Well Cementing Co. v. Walker, 329 U. S. 1, 67 S. Ct. 6, 91 L. Ed. 15 ..... 9, 10

Hotchkiss v. Greenwood, 11 How. (52 U. S.) 248, 13 L. Ed. 683 3

Jones v. Morehead, 1 Wall. (68 U. S.) 155, 17 L. Ed. 662 3

Kneeland v. American Loan & Trust Co., 138 U. S. 509, 11 S. Ct. 426, 34 L. Ed. 1052 1

Missouri-Kansas-Texas Railroad Company v. Texas, 275 U. S. 494, 48 S. Ct. 82, 72 L. Ed. 391 1

P. E. Sharpless Co. v. Crawford Farms, Inc. (C. C. A. 2), 287 Fed. 655 8

Phillips v. Page, 24 How. (65 U. S.) 164, 16 L. Ed. 639 3

Roemer v. Simon, 95 U. S. 214, 24 L. Ed. 384 3

Schriber-Schroth Co. v. Cleveland Trust Co., 305 U. S. 47, 59 S. Ct. 8, 83 L. Ed. 34; 304 U. S. 587, 58 S. Ct. 1052, 82 L. Ed. 1548 6

Stimpson v. Woodman, 10 Wall. (77 U. S.) 117, 19 L. Ed. 866 3

Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation (C. C. A. 9), 146 F. (2d) 941 ..6, 7, 8

Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation (C. C. A. 9), 58 U. S. P. Q. 293 6

Texts.

"Root Nodule Bacteria and Leguminous Plants," Edwin Broun Fred, Ira Lawrence Baldwin and Elizabeth McCoy, University of Wisconsin Studies 4

Walker on Patents (Deller's Ed.) Vol. 1, § 14, p. 55 ... 8

In the Supreme Court of the United States

OCTOBER TERM, A. D. 1947.

No. 280.

FUNK BROTHERS SEED COMPANY,
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Respondent.

REPLY BRIEF FOR PETITIONER.

Respondent's brief contains unfortunate insinuating and abusive language reflecting upon Counsel. We leave the matter to this Court for such action as it may care to take. *Missouri-Kansas-Texas Railroad Company v. Texas*, 275 U. S. 494; *Kneeland v. American Loan & Trust Co.*, 138 U. S. 509, 513.

The Petitioner, on page 1 of Respondent's brief, is charged with a misinterpretation and distortion of the opinion of the Court below, and with presenting a false issue before this Court. This statement has no foundation except as an utterance of the Respondent.

THE ISSUE PRESENTED.

The issues in this case, from its inception, have been (1) that the Bond theory of inhibition between different species of the legume bacteria is not true as a general condition, and (2) if the Bond theory is true, then Bond in discovering this fact merely discovered the workings of the laws of nature with respect to the functioning of the bacteria in the mixed inoculants of the prior art; and nothing more was added by Bond to constitute invention of a composition of matter.

The claims of the Bond patent include as the alleged feature of novelty the natural functioning of the legume bacteria, namely, that the bacteria do not inhibit one another, but no change in method, composition or mechanism results. (Please note claim 4, Petitioner's brief, page 1.)

When the Court below held "* * * the discovery of a natural phenomenon, or of a quality or attribute of a well-known article and application of that quality in a successful combination which is of value to mankind, is entitled to patent protection;" (R. 824) we submit that the issue, made by the Circuit Court of Appeals, of whether a discovery of a law of nature of the natural functioning of bacteria is patentable, is clearly presented.

The error of the Circuit Court of Appeals, and of the Respondent, is in the assumption that the Bond inoculant was new because of the discovery of Bond, and because it was new, it therefore was patentable.

The essence of Respondent's position is that Bond's alleged discovery of the non-inhibitive character of bacteria was new, and a product which contained this kind of bacteria was therefore patentable. Unfortunately for Respondent, this is not the law, which is nowhere better stated than by Mr. Justice Clifford in *Collar Co. v. Van Dusen*, 23 Wall. 530, 563, 23 L. Ed. 128 when he said:

> "Articles of manufacture may be new in the commercial sense when they are not new in the sense of the patent law. New articles of commerce are not patentable as new manufactures, unless it appears in the given case that the production of the new article involved the exercise of invention or discovery beyond what was necessary to construct the apparatus for its manufacture or production.*
>
> "Nothing short of invention or discovery will support a patent for a manufacture any more than for an art, machine, or composition of matter, for which

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* *Glue Company v. Upton*, 6 Official Gazette, 840.

proposition there is abundant authority in the decisions of this Court.†"

In *Boston Pencil Pointer Co. v. Automatic Pencil Sharpener Co.* (C. C. A. 2) 276 Fed. 910, 912, the Court said:

> "Further, it is settled that articles may be new in a commercial sense, when they are not new in the sense of the patent law (*Collar Co. v. Van Dusen*, 23 Wall. 530, 23 L. Ed. 128), and novelty, however great, can never be put in the place of invention (*Robins v. Link Belt*, 233 Fed. 1005, 148 C. C. A. 15). * * *"

Hence, we do not press lack of novelty by way of anticipation in this Court for the issue is moot. Novelty, utility or commercial success alone will not sustain invention.

The District Court presented the issue, and decided it, as follows (R. 744):

> "I find that the claims in suit of the Bond patent are invalid under our patent statute because they do not involve the invention or discovery of 'any new and useful art, machine, manufacture, or composition of matter.'"

The Circuit Court of Appeals reversed the District Court on this point—that is the issue.

Thus, it is apparent that there are no "concurrent findings of the courts below" on the real issue of the case, as alleged by Respondent on page 8 of its brief.

RESPONDENT'S "RESTATEMENT OF THE FACTS" STATES A PROBLEM THAT WAS NOT IN EXISTENCE.

Respondent, on pages 3 to 8 of its brief, states that mixed inoculants had "fallen into disrepute" merely because they were mixed inoculants, and further states that Bond faced an apparently unsolvable problem. This is

† *Hotchkiss v. Greenwood*, 11 How. 265; *Phillips v. Page*, 24 How. 167; *Jones v. Morehead*, 1 Wall. 162; *Stimpson v. Woodman*, 10 Wall. 121.

See also:

Dunbar v. Meyers, 94 U. S. 187, 196, 197.
Roemer v. Simon, 95 U. S. 214, 217, 218.

incorrect, but even if correct, it would not change the question here presented.

The Respondent admits that mixed cultures were recognized, and their advantages were known, as early as 1907, and that these mixed inoculants were advertised and placed on the market (Respondent's brief, page 4).

If Bond did anything at all, he merely discovered that occasionally, the legume bacteria when mixed together, would have a detrimental effect on one another, and then claimed in his patent a product that does not contain such bacteria. This is merely the use of a new finding of the natural functioning of the bacteria acting according to the law of their nature.

The "Bible" of the inoculant industry published in 1932 and entitled "Root Nodule Bacteria and Leguminous Plants" by Edwin Broun Fred, Ira Lawrence Baldwin and Elizabeth McCoy, University of Wisconsin Studies, referred to in Respondent's brief, page 4, shows clearly that inoculants generally, regardless of whether they were single or mixed inoculants, were not held in high repute. It states (Plaintiff's Exhibit 13, R. 401), "Unfortunately, those in charge of the preparation of these cultures have not always made use of the scientific facts as laid down by the early workers in the field. **The proper application of the scientific discoveries** would no doubt have prevented much of the disappointment and loss from the use of poor cultures."[1] (Emphasis ours.)

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[1] The Respondent, on pages 5 to 7 of its brief, would lead this Court to believe that extensive scientific investigations had been made by those skilled in this art to determine the "causes of the failure of mixed cultures to provide the same degree of nitrogen fixation as single cultures prior to the Bond invention."

Such is not the fact, as admitted by Plaintiff's witness, Robert H. Burris, who stated that "Nobody was particularly interested in it." (R. 349.) At least, the scientific world was not interested in the alleged problem so readily put forward by the Respondent as that which presented itself to Bond at the time of his invention.

(Continued on following page)

THE SEED INOCULANT INDUSTRY IS CONCENTRATED IN OR SUBJECT TO THE SEVENTH CIRCUIT.

Petitioner presents herewith an affidavit of Miles M. Elmers, General Manager of Agricultural Laboratories, Inc., of Columbus, Ohio, of which the Petitioner is a major distributor. His company has assumed the defense of this case and is therefore bound by the decision.

This affidavit is submitted to show the true condition of the inoculant industry for it is believed the affidavit of Myron E. Lusk is based on insufficient or incomplete information. Only passing comment need be made of the

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(*Continued from preceding page*)

The ~~Petitioner~~ RESPONDENT could find no article by any scientist of real repute to support its position and was forced to rely upon one by Max Kronenberger of the Bavarian Cultural Institute for Plant Culture and Plant Protection, Munich, Germany (PX-11, R. 383, 394), as the basis for its statement of the problem that allegedly existed. This article is clearly refuted by the scientific investigations made by Petitioner's expert witnesses in the reports of their investigations (DX-5, R. 446; DX-7, R. 471; DX-13, R. 482 to 487; DX-29, R. 670, 671), which show that the normal expected condition, when the legume bacteria are mixed together, is that a beneficial result will be obtained by the mixture rather than a detrimental effect, as alleged by Bond. Significantly, Kronenberger alleges *every* mixed culture is detrimental; Petitioner's experts found only an occasional possibility of detrimental effect. We leave it to the Court whether Kronenberger, whom Petitioner had no opportunity to cross-examine, or Petitioner's experts, whom Respondent did cross-examine without effect as to the validity of their findings, will be believed.

Respondent's brief, on page 6, would infer that Petitioner's expert, Dr. Lewis Erdman, demonstrated the impracticability of mixed cultures. Dr. Erdman's statement quoted by Respondent could apply only when a plurality of different bacteria are actually *grown* together. This statement does not apply when bacteria are grown separately and then mixed together. Dr. Erdman clearly stated that he could very easily produce the Bond mixed culture merely by mixing bacteria together. (R. 145.)

> "We could grow a pure culture liquid suspension of a selected number of strains of alfalfa group bacteria in one tank. In another tank we could grow the red clover group of bacteria, and in a third tank our selected strains of soybean bacteria. We could mix these suspension separately with the humus and then mix equal portions of the alfalfa, clover and soybean Nitragin. This would be the equivalent of Uni-Culture." (The Bond product.)

affidavit of Mr. Lusk, for when he avers there are two companies manufacturing inoculants for the years 1943 and 1944, to which the United States Department of Agriculture Circular No. 724 refers, he fails to specify the companies. Either they did not exist, or they are too small to be a factor in the industry. One of them could not be the Pearson and Company of Mobile, Alabama for this company was not commercially producing inoculants in 1944.

On the basis of Petitioner's verified assertion of the concentration of the inoculant industry in the Seventh Circuit, the rule applied by this Court in *Schriber-Schroth v. Cleveland Trust Co.*, 305 U. S. 47 applies here.

THE OPINION OF THE COURT BELOW IS IN CONFLICT WITH THE DECISIONS OF THE CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT.

There is no difference between the two opinions[1] of the Circuit Court of Appeals for the Ninth Circuit in the *Vitamin Technologists* case on the law of nature issue.[2] Both opinions held that a newly discovered effect of the workings of a law of nature cannot be patented. (58 U. S. P. Q. 295, 146 F. (2d) 948, 949.) The result has always been there, even though man knew nothing about it.

In the first opinion, the Court stated that "Steenbock's valuable scientific certitudes are discoveries, but

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[1] First opinion reported only at 58 U. S. P. Q. 293. Second opinion reported at 146 F. (2d) 941.

[2] Respondent (pages 15 and 16 of its brief) states that there is no conflict of opinion between the Circuit Courts of Appeals for the Seventh Circuit and for the Ninth Circuit merely for the reason that the Hon. Evan A. Evans, Senior Circuit Judge of the Seventh Circuit, referred to the decision of *Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation*, cited in 58 U. S. P. Q. 293, in his speech before the Pittsburgh Patent Law Association, referred to in Petitioner's brief, page 27, and not the final decision of the Court of Appeals for the Ninth Circuit, reported at 146 F. (2d) 941. But, the effect of the decision in 58 U. S. P. Q. 293, and even much of the language, is carried forward into the decision at 146 F. (2d) 941.

they are not inventions within the meaning of the term invention as used by the Congress in its Patent Laws." (Page 295.) (Emphasis ours.) The Court did not retract the statement or reverse itself in the second decision. The Court merely stated that Steenbock did not seek a monopoly of a "natural force" *per se*. The Circuit Court of the Ninth Circuit did hold in the second decision, *as in its first decision*, that the irradiation process had been accomplished "from time immemorial by the farmer in hay-curing in the sun and the coconut grower sun-drying the cut meat of the coconut." (Page 949.)

In the second decision, the Court elaborates its position to say that the use of ultra-violet rays "as a part of a process * * * to activate the antirachitic principle in lipoids processed by exposure to lamp rays" (146 F. (2d) 949) would be patentable, but the idea was old as having been done by natural processes "from time immemorial."

So in this case, while if Bond might have discovered something that man did not previously know, or understand, yet what he discovered has been going on as a natural process in every mixed inoculant ever produced,—the non-inhibited kind of bacteria would not be affected by the presence of other bacteria while the inhibited kind would be.

Certainly, Judge Healy, who wrote a concurring opinion in the first decision in the *Vitamin* case, still believes the issue of the patentability of a discovery of a natural phenomenon and mere use of that discovery without more, is present in the second decision (146 F. (2d) 941), for in the second decision he amplified his first concurring opinion and stated **"I think the Steenbock patents are subject to an infirmity still more fundamental"** (page 954), that the Steenbock invention **"would amount to no more than the ascertainment of a naked fact or principle in nature existing independently of the efforts of the discoverer."** (Page 954.) (Emphasis ours.) This final state-

ment of Judge Healy has previously been referred to in Petitioner's brief, page 25.

Thus, we submit, that since Judge Evans disagreed with the statements in the first *Vitamin* decision bearing on "discoveries" of benefit to man, we can see no conclusion to draw but that he disagrees with the statements in the second decision. Therefore, the decision in *Dennis v. Pitner,* 106 F. (2d) 142, which was cited and followed in the case at bar, and the case at bar, conflicts with the decision of the *Vitamin* case, 146 F. (2d) 941.

THE BOND PRODUCT IS NOT A PATENTABLE COMPOSITION OF MATTER UNDER R. S. 4886.

The Respondent, on pages 19 and 20 of its brief, states that a "composition of matter," only presupposes a combination of elements, and infers by its quotation from *Walker on Patents,* Dellers Edition, Sec. 14, page 55, that all composite articles are patentable whether they be the result of chemical union or mechanical mixture, assuming novelty is present.

The Respondent omitted the real gist of Sec. 14 of *Walker on Patents* when it failed to refer to the case of *P. E. Sharpless Company v. Crawford Farms, Inc.,* 287 Fed. 655, 658 (C. C. A. 2), referred to in Petitioner's main brief page 37, and quoted from in Sec. 14, page 55 of *Walker on Patents* as follows:

> "A patentable composition of matter may well result or be formed by the inter-mixture of two or more ingredients **which develop a different or additional property or properties which the several ingredients individually do not possess in common.**" (Emphasis ours.)

Walker on Patents goes further to state in Sec. 14, page 55:

> "* * * a composition of matter cannot be patented even though it is a product made artificially for the first time, if the product was set forth as a well-known

substance (*Cochrane v: Badische Anilin & Soda Fabrik*, 111 U. S. 293, 311)."

Thus, the Bond mixed inoculant, which is only a mixture of two entirely independently acting elements, does not involve an invention under Patent Statute R. S. 4886 for it does not meet the criteria of a truly patentable composition of matter.

THE CLAIMS OF THE BOND PATENT ARE INVALID WITHIN THE MEANING OF HALLIBURTON OIL WELL CEMENTING CO. v. WALKER, 329 U. S. 1.

The Respondent, on page 24 of its brief, misconceives the decision of *General Electric Company v. Wabash Appliance Corporation*, 304 U. S. 364 in its effort to avoid the effect of the opinion of this Court in *Halliburton Oil Well Cementing Co. v. Walker*, 329 U. S. 1. In the *General Electric* case, the Court stated:

> "But the vice of a functional claim exists not only when a claim is 'wholly' functional, if that is ever true, but also when the inventor is painstaking when he recites what has already been seen, **and then uses conveniently functional language at the exact point of novelty.**[11] " (p. 371.) (Emphasis ours.)

The Bond claims are wholly within the condemnation of the use of broadening functional language at the point of alleged novelty, so aptly quoted from the *General Electric* case by Respondent on page 25 of its brief.

Here, there is no limiting of the Bond claims by the recitation of the non-inhibitive character of the bacteria, for the functional language includes bacteria that not only do not inhibit one another under the alleged Bond invention, but to the contrary, have a beneficial effect on one another. Therefore, through the use of this functional language, the claims are broader than any alleged inven-

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[11] See *Gynex Corp. v. Dilex Institute*, 85 F. (2d) 103, 105; *Davis Co. v. New Departure Co.*, 217 F. 775, 782.

tion of Bond, and are invalid under the decisions in the *General Electric* case and *Halliburton v. Walker*.

Respectfully submitted,

H. A. TOULMIN, JR.,

Attorney for Petitioner.

H. A. TOULMIN, JR.,
D. C. STALEY,
Of Counsel.

In the Supreme Court of the United States

OCTOBER TERM, A. D. 1947.

No. 280.

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

AFFIDAVIT OF MILES M. ELMERS.

STATE OF OHIO,
COUNTY OF MONTGOMERY, ss:

I, Miles M. Elmers, being duly sworn depose and say:

That I am General Manager of Agricultural Laboratories, Inc., manufacturer of the accused product that has assumed the defense of the above-entitled case, and of which the Petitioner is a major distributor.

I have been engaged in the business of manufacturing and selling inoculants for leguminous plants since 1930, and I am familiar with the inoculant business done in the United States by all of the manufacturers of inoculants and with the inoculants produced by substantially all of the manufacturers.

I have read the Affidavit of Myron E. Lusk, General Manager of Kalo Inoculant Company, Respondent in the above-entitled case, and I cannot agree that the statements contained therein accurately set forth the true conditions in the inoculant industry. I regularly study the business done by Agricultural Laboratories, Inc. to compare it with the general inoculant business done in the United States by the inoculant industry as a whole to determine generally

the percentage of business that is being obtained by Agricultural Laboratories, Inc., and the quality of its products relative to the other major inoculant companies in the industry.

I am entirely familiar with the United States Department of Agriculture publication, Circular No. 724, referred to on page 31 of Petitioner's brief, and with other publications of this same character published by several of the states and state universities. It is my understanding that the publications of the United States Department of Agriculture of the character of Circular No. 724 are the most complete publications showing inoculant products marketed each year in the United States, and the source and manufacturer of the products. The United States Department of Agriculture endeavors annually to pick up samples of every inoculant marketed in the United States to determine its value and to prevent fraudulent products from being sold to the agriculturalist. To my knowledge, the list of manufacturers given in Circular No. 724 is a complete list of all manufacturers of legume inoculants that were of any importance in the inoculant industry during the period which the circular covers, and still represents all of the major manufacturers of legume inoculants.

The Pearson & Company of Mobile, Alabama, referred to by Myron E. Lusk in his Affidavit, first marketed its product in the Fall of 1945, which is subsequent to the period covered by the said Circular No. 724, and has never been a significant factor in the inoculant industry, doing less than 1% of the total business of the industry.

I have made a careful analysis of the inoculant industry based on my knowledge of the business done by Agricultural Laboratories, Inc. and on information I have received from reliable individuals of other major manufacturers of inoculants, and am able to reliably state that the manufacturers listed in Petitioner's brief pages 31 to 33 as those being within the Seventh Circuit, and Agricultural

Laboratories, Inc. do from 90 to 95% of the gross business in the inoculant industry. On the basis of this analysis the business done by the various manufacturers located within the Seventh Circuit, which are all of the major manufacturers of inoculants, except Agricultural Laboratories, Inc., located in the Sixth Circuit, but subject to the decision in this case, can be broken down as follows:

The Nitragin Co., Inc.	Milwaukee, Wisc.	35%
The Albert Dickinson Co.,	Chicago, Ill.	20%
The Urbana Laboratories,	Urbana, Ill.	15%
Kalo Inoculant Co.,	Quincy, Ill.	10%
Agricultural Laboratories, Inc.,	Columbus, Ohio	10%
Hansen Inoculator Co.,	Urbana, Ill.	5%
All others		5-10%

Based on my experience in the inoculant industry, I do not believe the statement of Myron E. Lusk "that over 75% of the total inoculant business done by companies located in or subject to the Seventh Circuit, consists of two single-culture inoculants for two legumes that normally are not grown in the same parts of the country. Consequently, these two single-culture inoculants are never handled in substantial quantities by the same dealers, and the Bond mixed culture therefore has no economic application to these." The companies listed above all manufacture inoculants for clover and alfalfa, to which the Bond mixed culture applies, and these crops are grown universally over the United States, and it is the increasing practice of agriculturalists to sow clover and alfalfa seed together. Consequently, the Bond patent relating to composite cultures for these crops, will have a great economic effect on the raising of these crops.

The inoculant industry is one in which the six manufacturers listed above are substantially the entire industry. The total annual sales are far greater than that indicated by Myron E. Lusk in his Affidavit and were larger in 1941 as calculated at $953,204 by Mr. Lewis T. Leonard, former

head of the United States Department of Agriculture, Bureau of Plant Industry, Soils and Agricultural Engineering, now retired, after a visit to all of the major manufacturers of the industry, a copy of whose letter is reproduced herein and attached to this affidavit.

Based upon my own analysis and on information that I believe to be reliable, received from other manufacturers of inoculants, it is my belief that the inoculant industry today amounts to at least $1,500,000 per year. In addition, there are many billions of dollars of agricultural products that are dependent on the inoculant industry for economical and efficient production.

MILES M. ELMERS.

Sworn to before me this 16th day of September, 1947.

MARIETTA J. REDELBERGER,
Notary Public, Montgomery County, Ohio.

(Notarial Seal)

MARIETTA J. REDELBERGER, Notary Public
In and for Montgomery County, Ohio
My Commission expires June 7, 1948

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
Research Center,
Beltsville, Maryland

Division of
Soil Microbiology

March 19, 1941

Mr. M. M. Elmers,
Agricultural Laboratories, Inc.,
3415 Milton Avenue,
Columbus, Ohio.

Dear Mr. Elmers:

Since returning from my trip during which I visited all but three or four of the inoculant producers and these latter of minor importance, I have calculated the gross of the industry at $953,204 from the data collected.

I appreciate very much your courteous treatment on the occasion of my recent visit to your plant.

Yours very truly,

LEWIS T. LEONARD,
MPL
Lewis T. Leonard, Bacteriologist.

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In the Supreme Court of the United States

OCTOBER TERM, A. D. 1947.

No. 280.

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

BRIEF FOR PETITIONER.

H. A. TOULMIN, JR.,
Attorney for Petitioner.

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INDEX.

The Opinions Below 1

Jurisdiction 1

Statement of the Case 2

The Issue 3

The Subject Matter 4

The Art Prior to Bond 4

The Alleged Invention of Bond 9

The Essence of the Bond Invention 13

Holding of the Courts Below 15

The Errors Assigned and to be Argued 16

Summary of Argument 16

Argument 19

I. No Patent Can Be Sustained for Monopoly of a Law of Nature of a Product or Composition of Matter 19

The Subject of the Bond Patent is Not Within the Classification of R. S. 4886 27

II. Can the Discoveries of the Laws of Nature and of Natural Products, Without Further Contribution By the Discoverer, Be the Subject of Patent Monopoly Under the Patent Statute R. S. 4886, Or Do They Belong to the Public? 28

III. An Old Product or Products of Nature in Combination Cannot Be Patented By a Mere Discovery Of a New Quality Existing In Nature. Under Sec. R. S. 4886 a Combination to Be Patentable Must Be Both New and Useful and Based Upon a Contribution to the Public Not Existing In Nature 33

Vitamin Technologists Case 36

IV. A Product Claim That Relies For Its Novelty Upon a Statement of Function is Invalid 38

Patentability of a Claim Involving a Mental Operation 39

Non-Patentability of Therapeutic Methods 41

V. Public Importance 42

APPENDICES:

A. Pertinent Statutes 44

B. Bond Claims in Suit 46

C. Excerpt From Judge Healy's Concurring Opinion in Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation, 146 F. (2d) 941, 954 (C. C. A. 9) 48

TABLE OF AUTHORITIES.

Cases.

Altoona Public Theatres, Inc. v. American Tri-Ergon Corp. et al., 294 U. S. 477, 55 S. Ct. 455, 79 L. Ed. 1005 35

American Fruit Growers, Inc. v. Brogdex Company, 283 U. S. 1, 51 S. Ct. 328, 75 L. Ed. 801 27

Boston Pencil Pointer Co. v. Automatic Pencil Sharpener Co. (C. C. A. 2) 276 Fed. 910 31

Brinkerhoff, Ex parte, Commissioner's Manuscript Decision, Vol. 24, page 349, Case No. 132; 27 J. P. O. S. 797 ..... 41, 42

Burr v. Duryee, 1 Wall. 531, 17 L. Ed. 650 25

Cochrane v. Deener, 94 U. S. 780, 24 L. Ed. 139 41

Collar Co. v. Van Dusen, 23 Wall. 530, 23 L. Ed. 128 ... 30

Cuno Engineering Corporation v. Automatic Devices Corporation, 314 U. S. 84, 62 S. Ct. 37, 86 L. Ed. 58 29

DeForest Radio Co. v. General Electric Co., 283 U. S. 664, 51 S. Ct. 563, 75 L. Ed. 1339 ..... 24-25, 35

Dennis et al. v. Pitner et al., 146 F. (2d) 142 15

Don Lee, Inc. v. Walker, 61 F. (2) 58 (C. C. A. 9) 40

Foley, Admx. of Gathmann v. U. S., 260 U. S. 667, 43 S. Ct. 240, 67 L. Ed. 451 35

General Electric Co. v. DeForest Radio Co. (C. C. A. 3), 28 Fed. (2d) 641 26

General Electric Co. v. Wabash Appliance Corp., 304 U. S. 364, 58 S. Ct. 899, 82 L. Ed. 1402 ..... 39, 40

Halliburton Oil Well Cementing Co. v. Walker et al., 329 U. S. 1, 67 S. Ct. 6, 91 L. Ed. 15 ..... 2, 38, 40, 41

Hazel-Atlas Glass Co. v. Hartford-Empire Co., 322 U. S. 238, 64 S. Ct. 997, 88 L. Ed. 1250 42

Holland Furniture Co. v. Perkins Glue Co., 277 U. S. 245, 48 S. Ct. 474, 72 L. Ed. 868 41

Hotchkiss v. Greenwood, 11 How. 248, 13 L. Ed. 683 ... 34

J. E. Baker Company v. Kennedy Refractories Company et al. (C. C. A. 3), 253 Fed. 739 25

LeRoy et al. v. Tatham et al., 14 How. 156, 14 L. Ed. 367 ..... 22, 23, 24, 36

Mackay Radio & Telegraph Co. v. Radio Corporation of America, 306 U. S. 86, 59 S. Ct. 427, 83 L. Ed. 506 31

Mercoid Corp. v. Mid-Continent Investment Co., 320 U. S. 661, 64 S. Ct. 268, 88 L. Ed. 376 42

Mills, Ex parte, 366 O. G. 477 42

Morton v. New York Eye Infirmary (C. C. N. Y. 1862), Fed. Cas. 9865, 17 Fed. Cas. 881 ..... 20, 36, 42

Morton Salt Co. v. Suppiger Co., 314 U. S. 488, 62 S. Ct. 402, 86 L. Ed. 363 42

Novocol Chemical Manufacturing Co., Inc. v. Powers & Anderson Dental Company (C. C. A. 4), 128 F. (2d) 904 27

O'Reilly et al. v. Morse et al., 15 How. 62, 14 L. Ed. 601 23

Old Town Ribbon & Carbon Company, Inc. v. Columbia Ribbon and Carbon Mfg. Co. (C. C. A. 2), 159 F. (2d) 379 ..... 34, 38

P. E. Sharpless Co. v. Crawford Farms, 287 Fed. 655 (C. C. A. 2) 28

Precision Instrument Manufacturing Co. et al. v. Automotive Maintenance Machinery Co., 324 U. S. 806, 65 S. Ct. 993, 89 L. Ed. 1381 43

Rubber Tip Pencil Company v. Howard, 20 Wall. (87 U. S.) 498, 22 L. Ed. 410 35

Smith v. Nichols, 21 Wall. 112, 88 U. S. 112, 22 L. Ed. 566 24

Standard Brands, Inc. v. National Grain Yeast Corporation, 308 U. S. 34, 60 S. Ct. 27, 84 L. Ed. 17 38

Telephone cases, 126 U. S. 1, 8 S. Ct. 778, 31 L. Ed. 863 24

Toledo Pressed Steel Co. v. Standard Parts, Inc., 307 U. S. 350, 59 S. Ct. 897, 83 L. Ed. 1334 34

Union Carbide Co. v. American Carbide Co. (C. C. A. 2), 181 Fed, 104 25

United States v. Masonite Corp., 316 U. S. 265, 62 S. Ct. 1070, 86 L. Ed. 1461 42

Universal Winding Co. v. Foster Machine Company, 16 F. Supp. 671 (D. C. Mass.), affirmed (C. C. A. 1) 90 F. (2d) 472 26

Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation, 146 F. (2d) 941, C. C. A. 9 ..... 36, 37

Statutes.

R. S. 4886, 35 U. S. C. A. 31 ..... 2, 3, 16, 17, 28, 29, 30, 32, 33, 44

R. S. 4888, 35 U. S. C. A. 33 ..... 18, 44

28 U. S. C. 347 1

In the Supreme Court of the United States

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No. 280.

FUNK BROTHERS SEED COMPANY,
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BRIEF FOR PETITIONER.

THE OPINIONS BELOW.

The opinion of the Circuit Court of Appeals for the Seventh Circuit is reported at 161 F. (2d) 981. The decision of the District Court is unreported, but the Memorandum of Holdings of the Court is contained in the Record at page 744, the Findings of Fact and Conclusions of Law at pages 745 to 753, and the Judgment at page 754.

JURISDICTION.

This case is here on a writ of certiorari, under the provisions of U. S. Code Title 28, Sec. 347, granted October 13, 1947.

STATEMENT OF THE CASE.

The Respondent brought suit against the Petitioner for infringement of United States Letters Patent to Varley Sherman Bond, No. 2,200,532 issued May 14, 1940. Respondent limited its charge of infringement to the product claims of the patent,[1] except product claim 2.

Petitioner filed a counterclaim asking for a Declaratory Judgment as to the invalidity of the entire Bond patent for it also contains claims directed to a method of making the product.

The District Court held the product claims invalid on the ground that they did not involve "any new and useful art, machine, manufacture or composition of matter" (R. 744), under the Patent Statute R. S. 4886[2] but if valid, infringed and dismissed Petitioner's counterclaim.

Respondent appealed the decision of the District Court to the Circuit Court of Appeals for the Seventh Circuit (R. 755) and the Petitioner cross-appealed so much of the decision of the District Court as related to the dismissal of the counterclaim and the holding of infringement by the product of the Petitioner. (R. 759.)

The Circuit Court of Appeals for the Seventh Circuit reversed the District Court, holding the claims in suit valid, sustained the District Court's holding of infringe-

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[1] The product claims in suit are 1, 3, 4, 5, 6, 7, 8, 13 and 14. Claim 4 is an example (all claims in suit are in the Appendix page 46):

> "An inoculant for leguminous plants comprising a plurality of selected mutually non-inhibitive strains of different species of bacteria of the genus Rhizobium, said strains being unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific."

Please note that the claims describe the product in terms of function. *Halliburton Oil Well Cementing Co. v. Walker*, 329 U. S. 1, 9.

[2] R. S. 4886, 35 U. S. C. A. Sec. 31. See Appendix page 44.

ment of the claims in suit and reversed the District Court's dismissal of the Petitioner's counterclaim. (R. 834.)

THE ISSUE.

The Circuit Court of Appeals reversed the District Court's decision that the product claims of the Bond patent do not involve "a new and useful art, machine, manufacture or composition of matter" under the Patent Statute R. S. 4886.

This case involves the fundamental question of whether "the discovery of a natural phenomenon, or of a quality or attribute of a well-known article and application of that quality in a successful combination which is of value to mankind," as held by the Circuit Court of Appeals,[3] is patentable.

The position of the Petitioner, from the inception of the case, has been:

(1) that the Bond theory of inhibition between different species of the legume bacteria is not true as a general condition;

(2) if the Bond theory is true, then Bond in discovering this fact merely discovered the workings of the laws of nature with respect to the functioning of the bacteria in the mixed inoculants of the prior art; and nothing more was added by Bond to constitute invention of a composition of matter.

(3) Even under the assumption that Bond was the first to discover that non-inhibitive legume bacteria exist in nature, a mere selection of these natural elements and use of them in their natural form to produce their natural function without change in a well-known old composition is not patentable under the Patent Statute R. S. 4886.

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[3] Rec'd 824.

THE SUBJECT MATTER.

The Bond patent falls in the art of bacterial inoculants for use on the seed of leguminous plants to carry bacteria into the ground for the purpose of infecting the roots of leguminous plants. The leguminous plants are those that draw nitrogen from the air and fix it in the plant for conversion to organic nitrogenous compounds, so that when the plants are turned under the soil the nitrogenous compounds in the plants become available for absorption by subsequent crops. The purpose of the inoculant is to place in the soil the proper species of bacteria for the particular leguminous plants to increase the efficiency of the nitrogen fixation effect of the plants, and thus make more nitrogen available in the soil for subsequent crops.

THE ART PRIOR TO BOND.[4]

Many years ago, scientists in this art discovered that when bacteria of the genus Rhizobia infect the roots of leguminous plants, the plants would draw nitrogen from the air and fix it within the plant so that the nitrogen would become available in the soil for absorption by subsequent plant crops. "The mechanism of this nitrogen fixation is not understood at the present time," (R. 772, line 9) but it is a natural phenomenon or result caused by the natural functioning of the bacteria upon infecting the roots of the leguminous plants and in some mysterious way cause the plants to fix nitrogen from the air when the plant and the bacteria get together.

Scientists also discovered that the bacteria of the genus Rhizobia can be classified generally into six fairly well

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[4] Petitioner wishes to be distinctly understood that it does not urge anticipation by reason of the prior art because it makes no difference whether Bond's ideas are new or old—there is no invention. A discussion of the art is given as a background for understanding what Bond claims as invention, what he discloses, and what is admittedly old.

defined cross-inoculation groups.[5] By cross-inoculation group is meant that the bacteria for one group will not normally infect the roots of the leguminous plants of another group to cause the nitrogen fixation in the plant.

The scientists were not long in discovering that in the various species of bacteria of the several cross-inoculation groups there existed many individual strains of bacteria and that they vary greatly in their natural ability to fix nitrogen in the plants for which they are specific. Some of these individual strains are weak and thus inefficiently cause fixation of nitrogen in the plant whereas other strains are strong and thus cause efficient nitrogen fixation in the plant. Thus, it was soon found necessary to make every effort "to select strains of the bacteria which are known to be of decided benefit to the host plant, and to keep these tested cultures under conditions which will maintain the organisms in an active state." (P. X. 13, R. 401, 68.)

For many years those working in this bacteriological field have isolated many individual strains of bacteria of the several cross-inoculation groups and have tested the strains by a scientific test procedure that is known to all bacteriologists in this field, to determine the effectiveness of the various strains of the bacteria so that they could discard the weak strains and retain the strong strains from which a bacterial culture of value could be produced for use in the manufacture of satisfactory inoculants. (R. 48.) Such stock cultures are maintained at various universities and in the United States Department of Agriculture for

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[5]

Species	Cross-inoculation Group
Rhizobium trifolii	Red clover, crimson clover, mammoth clover, alsike clover
Rhizobium meliloti	Alfalfa, white and yellow sweet clovers
Rhizobium phaseoli	Garden beans
Rhizobium leguminosarum	Garden peas and vetch
Rhizobium lupini	Lupines
Rhizobium japonicum	Soy beans

distribution to the manufacturers of inoculants. (R. 198.) In addition, the manufacturers maintain their own stock cultures, some of which they have themselves isolated. (R. 198.)

The record shows that as early as 1907 and subsequently mixed inoculants in which there were a plurality of species of bacteria, were known and used,[6] as Bond admits. (R. 106.)

In 1916, Dr. Thomas F. Manns[7] and his assistant, Joseph M. Coheen, made an extensive investigation into the use of humus as a carrier for all beneficial legume bacteria, as well as a carrier for other plant fertilizers.[8] The conclusion of their work was that "in the light of recent investigations, the present work shows that the organisms for the different groups of the important agricultural legumes may be successfully carried in one and the same compost." (R. 532.)[9]

Also, mixed inoculants were on the market before the Bond invention in the form of packages of various size for use on garden beans, garden peas, lima beans, sweet peas and lupines, five cross-inoculation groups. In 1937 Mc-

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Petitioner's exhibits, Defendant below, are referred to herein as "DX...."; Respondent's exhibits, Plaintiff below, are referred to as "PX...."; and pages of the printed record as "R...."

[6] Mixed inoculants were known in prior patents and publications, DX-16, R. 508, R. 249; DX-17, R. 564, R. 256; DX-22, R. 636, R. 294; Patents to Earp-Thomas 865,965, R. 780; 1,099,121, R. 876; Manns 1,320,701, R. 804; and in commercial products DX-1, R. 440, R. 241; DX-4, R. 442, R. 241; DX-10, R. 476, R. 241; DX-11, R. 478, R. 241.

[7] Head of Department of Plant Pathology and Soil Bacteriology, University of Delaware, Delaware, N. J. (R. 244.)

[8] Bulletin No. 115, Delaware College Agricultural Experiment Station. (DX-16, R. 508-560, R. 249.)

[9] Additional excerpt from Defendant's Exhibit 16.

"Plate VII (R. 554)—Showing growth of five legumes, in sand culture, viz. alfalfa, crimson clover, vetch, cow peas and soy beans, representing as many different groups of B.radicicola. The amount of compost used was 2 lbs., 100 lbs., and 500 lbs. respectively. All showed strong inoculation indicating that in one compost all the groups may be successfully carried." (R. 547.)

Queen's, Inc., of Baltic, Ohio, placed on sale a ten-cent package of a mixed inoculant of the kind just referred to for use by home gardeners, and a market size package that was for inoculating ¼ bu. of seed for use by truck gardeners.[10] In fact, the method of producing the mixed inoculant at McQueen's is comparable to the method of preparing a mixed inoculant according to the Bond patent.[11] Also, Agricultural Laboratories, Inc., Columbus, Ohio, produced and sold a mixed inoculant following this same procedure before the advent of the Bond patent. (R. 168-171.)

There is no evidence of record in this case that would point to any reason why the early single inoculants or mixed inoculants were not satisfactory for the purpose for which they were used other than general difficulties in preparing and maintaining strong bacterial cultures.[12] In

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[10] Defendant's Exhibits 3 (R. 440, 241) and 4 (R. 442, 445, 241).

[11]

Bond's method of making a mixed inoculant.	McQueen's method of making a mixed inoculant.
1. Cultures several species of bacteria separately.	Cultures several species of bacteria in separate bottles. (R. 160, 162.)
2. Puts selected, "non-inhibitive" species together into a humus base.	Puts separately cultured bacteria together in a humus base. (R. 160.)
3. Humus base has "negligible concentration of nutrient."	Humus base had less nutrient in it than that of the Bond method. (R. 161.)
4. Puts the several bacteria in in numbers of "substantially the same order of magnitude."	Puts the several bacteria in in "substantially the same numbers for each of the different groups." (R. 166.)

[12] Plaintiff's Exhibit 13, Record 401, 68.

"Since 1903 the use of artificial cultures has developed rapidly. Unfortunately those in charge of the preparation of these cultures have not always made use of the scientific facts as laid down by the early workers in the field. The proper application of the scientific discoveries would no doubt have prevented much of the disappointment and loss from the use of poor cultures." (R. 401.)

fact, the record shows the contrary wherein the undisputed testimony of Dr. Hofer[13] is to the effect that a yield of lima beans produced from plants inoculated with a mixed culture was greater than when plants were inoculated with a single culture.[14] Dr. Lewis W. Erdman[15] testified that in the garden mixture of The Nitragin Co. (D.X. 11A and 11B, R. 479, 241) he uses the same strains of bacteria that are used in his single inoculant.[16] And that "we have been putting up this mixed culture for garden size for a period of years with very fine results." (R. 237.)

In these prior mixed inoculants the individual species of bacteria would act according to their own law of nature. Man did nothing to change their natural functioning, and man does nothing today, including Bond, to change the natural functioning of the bacteria in mixed inoculants. Those strains of bacteria which were strong in their ability to fix nitrogen would function efficiently and those that were weak would function inefficiently, each acting according to its own law of nature. Bond will not dispute this,

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[13] Assistant Professor, Cornell University, Bacteriologist, New York State Agricultural Experiment Station. (R. 312.)

[14] This is according to tests performed by Dr. Hofer, Defendant's Exhibit 31, R. 673, 317.

[15] Director of Research and Production, for The Nitragin Co., Milwaukee, Wisconsin. (R. 220.).

[16] Dr. Erdman testified as follows (R. 223):

"In preparing our garden culture, we will use the same material for our regular production of pea culture, for instance, that is used by the canners or the seed pea growers; the same selection of strains that goes to make up that also goes into the production of our garden culture. The same is true for our bean culture. The same is true for our lima bean culture and lupine culture. All of these are included in our garden mixture."

and in fact admits that the prior mixed inoculants could have contained his "alpha" [17] strains of bacteria.[18]

THE ALLEGED INVENTION OF BOND.

With this background, we can evaluate Bond's contribution and right to control and monopolize a law of nature.

The patentability of the Bond inoculant is said to reside in his alleged discovery that some strains of the legume bacteria have natural characteristics such that they will not be inhibited by other strains in their ability to fix nitrogen in the leguminous plants when placed together—a natural phenomenon or law of nature. As Bond says: "* * * said cultures being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific." (Claim 1, R. 779.)

The reason for the alleged invention is, according to Bond, that prior to him "It has heretofore been considered impracticable to prepare a composite culture inoculant containing organisms which will cause nodulation on more than one of the cross-inoculation groups. This has not been done because it was generally believed that one species produced an inhibitory effect on another species within the same culture whereby symbiotic nitrogen fixation by the plant and the organism was inhibited or even prevented." [19]

Thus, Bond alleges that he made the discovery that of all of the numerous individual strains of bacteria that ex-

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[17] "Alpha" is the name given by Bond to the non-inhibitive strains of bacteria.

[18] Mr. Bond testified as follows on cross-examination:

"Q. It may have been given without showing the test that in this garden mixture there was what you now call an alpha strain of the bacteria?

A. There might have been. **There was no way to know, without running tests.**" (R. 133.)

[19] Bond patent, R. 774, line 70, column 1, to line 4, column 2.

ist in nature, some of them will not be inhibited in their ability to fix nitrogen by the presence of another in a base or carrier. Having made this discovery, Bond then proceeds in his patent to set forth a well-known test[20] to select his non-inhibitive or "alpha" strains by allowing them to act in their natural way on leguminous plants. Those strains of bacteria which, functioning according to the law of their nature, are not inhibited, are selected by Bond for use in an inoculant and have been named by him as "alpha" in the Bond patent. Those strains which, functioning according to the law of their nature, are inhibited, are discarded.

Thus, Bond permits the various strains of bacteria to work out their own destiny as intended by nature and

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[20] With reference to the test by which Bond selects a non-inhibitive strain of bacteria from an inhibitive strain, he testified as follows:

"Q. You selected the single strains which you propose to put in your mixture?

A. Yes.

Q. Now, you don't know whether that is an alpha strain or a non-alpha strain at that time, do you?

A. No.

Q. And you don't know any way of determining whether it is an alpha strain or a non-alpha strain except by subjecting it to a routine test.

A. Yes.

Q. Now, by an alpha strain I mean a strain as defined in your specifications, as one which has no inhibitory effect or is not affected by association with some other strain.

A. Yes.

Q. That is what we mean in the terms of your patent when referring to an alpha strain.

A. Yes.

Q. And this test that you subject your selected individual strains to, to determine whether they were alpha strains or not, was a routine, well known laboratory test.

A. Yes.

Q. The same as your efficiency test of a single strain, was it not?

A. Yes.

Q. You did not invent that test?

A. No, no." (R. 124.)

selects for use those strains which are not inhibited. **But, Bond admits the bacteria he selects are the same as found in nature, unchanged in any way.**[21]

The procedure in producing the alleged new product of Bond is as follows:

1. A species of bacteria is isolated from nature by a well-known laboratory technique that was known before the advent of the Bond patent. (R. 775, column 1, lines 17 to 22, R. 116.)

2. After the species of bacteria is isolated, it is cultured to cause it to multiply many times by laboratory technique known before the Bond patent (R. 115, 116), and which, as admitted by Bond, does not in any way modify or change the natural characteristics of the bacteria from that as it existed in nature. (R. 116.)

3. Standard routine tests, known in the art before the Bond patent (R. 116) are made to determine the efficiency of the particular species of bacteria in its ability to fix nitrogen. If it is an efficient specie, it is retained. If it is an inefficient specie, it is discarded.

4. This procedure of isolating and testing numerous individual strains of the several species of bacteria is followed until a plurality of efficient strains for each species of

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[21] Mr. Bond testified as follows:

"Q. When you get through with your culture you have the same bacteria you got from nature, but you have more of it, is that correct?

A. That is true; that is correct.

Q. And that was well-known in the art among those skilled in the art, prior to the date of your application for your patent or your claimed invention?

A. Yes, sir. (R. 116.)

Q. Therefore that means, does it not, that nothing that you have done to these bacteria brings about a state of inhibition or a state of non-inhibition.

A. No.

Q. **That is simply, then, the work of nature, and you apply tests to observe whether or not that physical fact of nature is in existence in these Rhizobia or is not in existence?**

A. **Yes.**" (R. 125.)

leguminous plant is found. This is an old testing procedure. (R. 116.)[22]

5. To make the "Bond" composite inoculant, the several efficient strains of each specie of the bacteria are then tested under standard technique known before the Bond patent (R. 124) to determine which of the strains of bacteria of each of the species is the most effective when the several species are mixed together.[23] If the bacteria in the inoculant that contains two or more independent species function in exactly the same way they do in nature working by themselves, then this particular strain of bacteria is selected by Bond as the "alpha" strain for use in his composite inoculant. (R. 777, column 1, line 36.)

6. One or more of the "alpha" strains are then used in the composite inoculant.

Bond admits that he isolates the various strains of bacteria by technique old before his patent. (R. 775, column 1, lines 17 to 24.) He admits that he cultures the bacteria by standard technique (R. 115, 116) and he admits that he does not change the material characteristics of the bacteria. (R. 116 and 125.) He admits his efficiency testing of the strains is standard practice known before his invention. (R. 116.) He admits the humus was no invention of his and that his method of placing the bacteria in the humus was no claimed invention of his. (R. 119.) He admits the

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[22] The Bond patent also states:

"* * * a number of strains of each of these organisms may be isolated from nature by any of the approved methods such as have been described in the above referred to Laboratory Manual of General Microbiology by Fred and Waksman." (R. 777.)

[23] The method of testing is an old procedure as stated in the Bond patent:

"The method for carrying out tests for determining the amount of nitrogen fixed by leguminous plants in association with the various species of the Rhizobia are well known in the art and are given in detail by Fred and Waksman, *supra*, and Fred, Baldwin and McCoy." (R. 777.)

test for his "alpha" strains was a well-known laboratory test. (R. 124.) **He admits that nothing he does to the bacteria brings about a state of inhibition or non-inhibition. It is simply a work of nature.** (R. 125.)[24]

THE ESSENCE OF THE BOND INVENTION.

The heart of the Bond invention thus rests upon his alleged discovery that non-inhibitive legume bacteria exist in nature and can be selected for use. Even these, however, follow their natural functions without any change by Bond. (R. 125.)

This contention of Bond was built upon a collection of more or less casual statements made by various writers prior to 1937[25] (the date at which Bond alleges to have made a study of the literature) (R. 54), and on tests allegedly made by him, but which were never substantiated or corroborated by any evidence introduced at the trial. Some of these tests are set forth in his patent (R. 778), but even here it was shown at the trial that his reported findings were not accurate. (R. 130.)

The alleged inhibitory effect is said to manifest itself in a lowering of the efficiency of the bacteria to fix nitrogen in the plants when the bacteria are used together in a common base as shown by a lesser amount of nitrogen in the plants upon making a chemical analysis of them.[26] Re-

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[24] See footnote 21, page 11, *supra*.

[25] The statements made by the various writers were either refuted or explained by Petitioner's witnesses, which were in several instances the authors of the statements.

[26] Bond sets forth the criterion in his patent as follows:

"One criterion by which the alpha strains of the organisms may be determined is based on a statistical comparison of the total milligrams of nitrogen fixed in plants previously inoculated with a single strain unmixed with strains of other species with the total milligrams fixed in plants inoculated with the same strain mixed with strains of other species." (R. 777.)

"• • • samples were analyzed by the Kjeldahl method for their nitrogen content." (R. 778.)

spondent's witness, Dr. Robert H. Burris,[27] testified that the Kjeldahl chemical examination is the only valid method of determining nitrogen content,[28] yet the Kronenberger article[29] so largely depended on by Respondent to support its contention of inhibition does not show any chemical analysis. Kronenberger's report is based entirely on a visual inspection of the general condition of the plants during growth and dry weight of the plants, which method of analysis and inspection was vigorously attacked by Respondent when these same kinds of tests were applied to show satisfactory results obtained by mixed cultures of the prior art.[30]

Further, Dr. Hofer's tests introduced at the trial[31] are in direct conflict with the Kronenberger article for the reason that Dr. Hofer did not find any inhibition where Kronenberger apparently did, even though Dr. Hofer prepared his inoculant by the same method that Kronenbereger prepared his,[32] and Dr. Hofer even made a chemical analysis of the nitrogen content of his plants. (R. 306 to 308.)

Contrary to the contention of Bond that one strain of bacteria inhibits another, Petitioner introduced evi-

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[27] Assistant Professor in Biochemistry, University of Wisconsin, Madison, Wisconsin.

[28] Record 346.

[29] "On Mutual Retardation and Favoring Between Nodule Bacteria." By Max Kronenberger; Bavarian Agricultural Institute for Plant Culture and Plant Protection, Munich, Germany. (P.X. 11, R. 383, R. 68.)

[30] Testimony of Ivan H. Curie, R. 201, 203, 210, 219.
Testimony of Dr. Lewis W. Erdman, R. 232.
Testimony of Lewis T. Leonard, R. 298.
Testimony of Dr. Alvin W. Hofer, R. 333.

[31] D.X. 26, R. 665, 306; D.X. 27, R. 667, 306; D.X. 28, R. 669, 306; D.X. 29, R. 670-671, 309.

[32] Dr. Hofer's method of preparing his inoculant is set forth in the record, page 304.
Kronenberger's method of preparing his inoculant is set forth in the record, page 385.

dence at the trial through its experts, I. H. Curie, L. W. Erdman and A. W. Hofer, of the results of tests that show the incorrectness of any contention that normally and generally one strain of bacteria is inhibited when it is placed in association with another strain of bacteria of another cross-inoculation group. Even assuming that Bond's discovery of the existence of inhibitive and non-inhibitive strains of bacteria is correct, the results of all tests introduced by the Petitioner show that inhibition, if it exists, is an exception,—not the rule, as alleged by Respondent and Bond.

Petitioner's position is this: It makes no difference whether Bond discovered inhibition or not. It makes no difference if it was new. It is still a law of nature, used without modification or creation of an art, machine, manufacture or composition of matter. It is, therefore, not invention.

HOLDING OF THE COURTS BELOW.

On the foregoing state of the facts the District Court held the claims in suit "invalid under our Patent Statute because they do not involve the invention or discovery of 'any new and useful art, machine, manufacture or composition of matter.'" (R. 744.)

The Circuit Court of Appeals for the Seventh Circuit in reversing the holding of the District Court assumed that when Bond discovered, if he did, the non-inhibitive strains of bacteria, that he made an invention, that Court stating (R. 824):

> "* * * the discovery of a natural phenomenon or of a quality or attribute of a well known article and application of that quality in a successful combination which is of value to mankind, is entitled to patent protection."

the Court following the dicta set forth in its prior decision in *Dennis et al. v. Pitner et al.*, ~~146~~ 106 F. (2d) 142.

THE ERRORS ASSIGNED AND TO BE ARGUED.

The errors assigned in the Petition for Writ of Certiorari and to be argued here are:

I. No Patent can be sustained for monopoly of a law of nature of a product or composition of matter.

II. Can the discoveries of the law of nature of natural products or composition of matter, without further contribution by the discoverer, be the subject of patent monopoly under the Statutes R. S. 4886 or do they belong to the public?

III. An old product or products of nature in combination cannot be patented by a mere discovery of a new quality existent in nature from time immemorial: Under Sec. R. S. 4886 to be patentable, the combination must be new and useful and based upon a contribution to the public not existing in nature.

IV. A product claim that relies for its novelty upon a statement of function is invalid.

V. Public Importance.

SUMMARY OF ARGUMENT.

The laws and phenomena of nature are a part of the tools of science that have not been brought within the field of protection of the patent law by statute or by interpretation of statute. These tools are a part of our storehouse of knowledge which shall remain free for all eternity for use by men in their continued efforts to reach a higher plane of living and endeavor. To cut short the future use of new discoveries of the laws or phenomena of nature, or of new qualities or attributes of products of nature, or old products, by awarding private patent monopolies on such discoveries will discourage arts and manufactures, against the avowed policy of the patent laws.

It makes no difference whether or not Bond was the first to discover previously unknown attributes of the legume bacteria and thus show that non-inhibitive strains of bacteria exist in nature. The use of these discovered at-

tributes is not patentable, for invention is not in the discovery of them. Here Bond does not control the bacteria, but to the contrary, he allows the bacteria to act according to their own law of nature and thus work out their own destiny as to their future use by him.

Mixed inoculants were known long before the Bond patent and all scientists in the art of legume bacteriology were constantly carrying forward the art for improvement. But, the mere carrying forward of an original thought, the mixed inoculant, a change in form, proportions, or degree, the substitution of equivalents, doing substantially the same thing in substantially the same way by substantially the same means with better results, is not invention as will sustain a patent.

The only way Bond can determine the existence of inhibitive or non-inhibitive strains of bacteria is to perform tests. No one can know whether he is or is not an infringer of the Bond Patent without performing tests, and even then may not know for tests are variable. But a patentee has no right to cause others to perform tests to determine the scope of his claims.

The patent statute R. S. 4886 requires that the subject of a patent shall be an "invention or discovery," shall be "new and useful" and shall be an "art, machine, manufacture, or composition of matter." When all of the criteria do not exist a patent cannot issue. The subject of the Bond Patent is not classifiable in the required classifications of the statute and even though the discovery of the phenomena of nature may be new, it merely displays itself in an old mixed inoculant. The patent statute is, therefore, not satisfied. The mere fact that an article is new commercially does not make it new patentably.

However skillfully Bond brought the non-inhibitive bacteria together in the old mixed inoculant, it was still the product of skill, not of invention. The non-inhibitive bac-

teria function in his product in the same way they have functioned in nature from time immemorial, either individually or when in association with other legume bacteria that exist in nature, with the inevitable result of fixing nitrogen in leguminous plants according to their own law of nature, unchanged, unmodified in anyway by Bond. It would be unsound to hold that merely because the manufacturers of mixed inoculants prior to Bond did not know they had inhibitive and non-inhibitive strains of bacteria in their product, they would now be infringers after Bond discovered the existence of non-inhibitive bacteria.

Further, to practice the Bond invention requires testing and mathematical calculations based upon those tests and the mental determination and analysis of the calculations before the existence or non-existence of the non-inhibitive strains of bacteria can be established, if it exists. Even then, this determination would be based on the experimenter's own calculations made as a result of the degree of skill that he was capable of employing. A skillful operator might find non-inhibition, an unskillful one would not. Such indeterminate determinations make the practice of the Bond invention incapable of clear definition as required by the patent statute (R. S. § 4888). The subject of the Bond Patent is defined only in terms of effect or function of the elements of the product.

This case is of great public interest in an age where our national security and prosperity are dependent upon the free use of scientific discoveries to promote our welfare. The public interest demands that there be no private monopoly of such results of scientific discovery, where the discovery merely unfolds the secrets of nature, previously hidden in the darkness of insufficient knowledge, but which, upon discovery, can be made a working tool of science for future progress. To deny this is to retard progress made possible by the skill of the scientist.

ARGUMENT.

I. NO PATENT CAN BE SUSTAINED FOR MONOPOLY OF A LAW OF NATURE OF A PRODUCT OR COMPOSITION OF MATTER.

The Bond Patent claims a monopoly of any inoculant containing bacteria of more than one of the cross-inoculation groups in which one or more strains of the bacteria are of a non-inhibitive kind.[33] It makes no difference whether the bacteria, functioning according to their own law of nature, are merely not inhibited when put in association with one another or whether they function better when placed in association with one another,—the Bond claims monopolize the use of bacteria in an inoculant so long as the bacteria is "unaffected by the others in respect to its ability to fix nitrogen in the leguminous plant."[33]

This monopoly of a mixed inoculant is urged by the Respondent regardless of the manner in which the inoculant is made. Bond endeavors to remove from the field of use by the inoculant industry any and all non-inhibitive strains of bacteria for use in mixed inoculants regardless of when the bacteria was discovered and regardless of how old the particular strain of bacteria may be, thus requiring any manufacturer of any mixed inoculant to scientifically test all of his strains of bacteria that he now holds as stock cultures to be sure that he uses only inhibitive strains when making a mixed inoculant, and if he has no inhibitive strains, to go out and find them.

The only basis for this monopoly is that Bond alleges that he discovered a previously unknown phenomenon of nature, that non-inhibitive strains of bacteria do exist,

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[33] Claim 5 illustrates the extreme breadth of the Bond Patent.

"An inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium, at least one of which strains is unaffected by the others in respect to its ability to fix nitrogen in the leguminous plant for which it is specific." (R. 779.)

whereas he claims, previously, it had been thought that the bacteria were inhibitive.

On the contrary, the evidence produced by the Petitioner at the trial concerning the question of whether or not inhibitive strains exist, clearly shows that when highly efficient strains of bacteria are merely mixed together in a common carrier or base, that under normal circumstances, with the bacteria acting according to their own law of nature, there will not be any inhibitory effect of one strain of bacteria with reference to another. And Bonds admits that manufacturers of inoculants use only highly efficient strains of bacteria,—there would be no sense in doing otherwise.[34]

This alleged discovery of Bond is no more than another discovery of a phenomenon of nature which exists as a part of our storehouse of knowledge, dormant, until some researcher delves into the intricate secrets of nature. Morton did this at the time of his discovery of the phenomenon of anaesthesia on the human body under the effect of ether. However, this discovery was held not patentable in *Morton v. New York Eye Infirmary* (C. C. N. Y. 1862), Fed. Cas. 9865, 17 Fed. Cas. 879, 881.

> "* * * In its naked ordinary sense, a discovery is not patentable. A discovery of a new principle, force, or law operating, or which can be made to operate, on matter, will not entitle the discoverer to a patent. It is only where the explorer has gone beyond the mere

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[34] Mr. Bond testified as follows:

"A. That is true, occasionally, there is a strain found that is not constant. That is, its nitrogen fixing ability may drop. But strains of that nature is the exception rather than the rule.

Q. But there are such strains?

A. They do exist. When the strain is observed to vary in that manner, it is not used in making a commercial product." (R. 120.)

"A. That is true, they are selected first, because there is no sense of even thinking of putting a culture in a product that isn't good in the first place." (R. 123-124.)

domain of discovery, and has laid hold of the new principle, force, or law, and connected it with some particular medium or mechanical contrivance by which, or through which, it acts on the material world, that he can secure the exclusive control of it under the patent laws. He then controls his discovery through the means by which he has brought it into practical action, or their equivalent, and only through them. It is then an invention, although it embraces a discovery. * * *"

Imagine the effect on human welfare and the restriction that would have been placed on the advancement of medical science if the discovery of the anaesthetic effect of ether when applied to the human body, would have been declared the subject of a valid patent. We submit the same far-reaching effect is now at stake in this case for in the last few years it is the common practice for farmers to seed their fields with a mixed seeding of clover and alfalfa.

If this alleged discovery of Bond is allowed to remain as a valid patent, it will stop all further progress in the bacteriological art as applied to the Rhizobium bacteria for use in agriculture. No manufacturer could put himself in the position of placing two or more species of bacteria together in a common carrier to inoculate any mixed seeding of any kind for fear of infringing the Bond patent. This, regardless of the fact that the species of bacteria the manufacturer placed together had been known to him and used by him with highly successful results for many years before the advent of the Bond patent, and regardless of the method by which he put these bacteria together.

Bond endeavors to monopolize an entire industry by a mere discovery of the law of the nature of the functioning of bacteria over which he has no control.

Bond does not claim that he discovered any new kind of bacteria, nor does he claim that he discovered any new principle by which the bacteria work. He does not claim that his method of culturing the bacteria is new, nor does he claim that his use of a humus base is new. Bond does

not claim that he has a product that was unknown before his patent, for mixed cultures were admittedly used before Bond. (R. 106.)

Bond does not claim that the bacteria work in any different way in his culture than they do in nature nor than they have worked in previous mixed cultures. He does not claim that they work other than according to their own law of nature. He admits that nothing that he has done makes any change in the way the bacteria work according to their own law of nature. (R. 125.) If the bacteria are of the inhibitive kind they will be inhibited; if they are not of that kind they will not be inhibited. **This is a natural function of the bacteria and nothing Bond does changes it.**

All that Bond can lay claim to is that in his mixed inoculant he takes advantage of the natural characteristics of certain strains of bacteria to make his mixed culture more efficient than the previous mixed cultures; and even he is doubtful of this fact for he admits that the mixed cultures of the prior art could have contained his non-inhibitive strains of bacteria. (R. 133.)[35]

Assuming for the purpose of argument that Bond did discover the fact that certain strains of bacteria, when acting according to the law of their nature, will not be inhibited when placed in association with other strains of bacteria from other cross-inoculation groups, this is merely a discovery of a scientific fact that has always existed or of a quality of the bacteria that had not previously been discovered by scientists. A newly discovered principle or quality of the bacteria or the manner in which they work in nature, is not patentable. As this Court has held in *LeRoy et al. v. Tatham et al.*, 14 How. 156, 175, 14 L. Ed. 367:

> "A patent is not good for an effect, or the result of a certain process, as that would prohibit all other persons from making the same thing by any means what-

[35] See footnote 18, page 9.

soever. This, by creating monopolies, would discourage arts and manufactures, against the avowed policy of the patent laws."

And this Court, in *O'Reilly, et al. v. Morse, et al.*, 15 How. 62, 117, 14 L. Ed. 601, when referring to its decision in the prior case of *LeRoy et al. v. Tatham et al., supra*, said:

> "It appeared that, in that case, the patentee had discovered that lead, recently set, would, under heat and pressure in a close vessel, reunite perfectly, after a separation of its parts, so as to make wrought instead of cast pipe. And the court held that he was not entitled to a patent for this newly-discovered principle or quality in lead; and that such a discovery was not patentable. * * *"

The discovery of the natural functioning of the bacteria is the only thread of alleged invention in the Bond patent. Even if this were new, the mere application of this discovery to the old mixed inoculant product without in any way changing the manner in which that old product functioned, except possibly in degree, is not invention. As this Court said in *LeRoy et al. v. Tatham et al., supra*:

> "* * * It is said, in the case of *The Househill Company v. Neilson*, Webster's Patent Cases, 683; 'A patent will be good, though the subject of the patent consists in the discovery of a great, general, and most comprehensive principle in science or law of nature, if that principle is by the specification applied to any special purpose, so as thereby to effectuate a practical result and benefit *not previously attained*.' * * *." (p. 175—emphasis ours.)

The issue here is—is such a discovery patentable when the patentee does nothing to change the natural characteristics of the bacteria, adds nothing to nor takes anything away from the bacteria, but merely uses the bacteria as selected by their own law of nature for use in an old and well-known product to produce the same and well-known function?

To allow such a discovery to now become the subject of a patent monopoly, as held by the Circuit Court of Appeals, is in direct conflict with the holding of this Court in *LeRoy et al. v. Tatham et al.*, 14 How. 156, 175, 14 L. Ed. 367:

> "* * * A principle, in the abstract, is a fundamental truth; an original cause; a motive; these cannot be patented, as no one can claim in either of them an exclusive right * * *
>
> "* * * In all such cases, the processes used to extract, modify and concentrate natural agencies, constitute the invention. The elements of the power exist; the **invention is not in discovering them, but in applying them to useful objects.** * * *" (Emphasis ours.)

In the *Telephone* cases, 126 U. S. 1, 532, 8 S. Ct. 778, 31 L. Ed. 863, it was the "new" and useful result, such as using a current from a battery in a particular type of circuit so that one puts a force of nature in a specific condition that is "new," which was patentable.

> "In this art—or, what is the same thing under the patent law, this process, this way of transmitting speech—electricity, one of the forces of nature, is employed; but electricity, left to itself, will not do what is wanted. **The art consists in so controlling the force as to make it accomplish the purpose.** * * *" (Emphasis ours.).

In *Smith v. Nichols*, 21 Wall. 112, 119, 88 U. S. 112, 22 L. Ed. 566, this Court said that—

> "* * * a mere carrying forward or new or more extended application of the original thought, a change only in form, proportions, or degree, the substitution of equivalents, doing substantially the same thing in the same way by substantially the same means with better results, *is not such invention as will sustain a patent.*" (Emphasis ours.)

The holding of the Circuit Court is in direct conflict with the holding of this Court in *DeForest Radio Co. v.*

General Electric Co., 283 U. S. 664, 684, 685, 51 S. Ct. 563, 75 L. Ed. 1339, wherein this Court stated:

"* * * It is method and device which may be patented and not the scientific explanation of their operation. See *LeRoy v. Tatham*, 14 How. 156, 174-6."

In *Burr v. Duryee*, 1 Wall. 531, 570, 17 L. Ed. 650, this Court stated:

"* * * We find here no authority to grant a patent for a 'principle' or a 'mode of operation,' or an *idea*, or any other abstraction. * * *"

But Bond does not make any change in or modify the bacteria used in his product and did not create a substance which never existed, for mixed inoculants were old. All that Bond can say is that his substance is more efficient than the old substance. That was not the case in *Union Carbide Co. v. American Carbide Co.* (C. C. A. 2), 181 Fed. 104, 105, relied upon by the Circuit Court in support of the Bond invention, for there the patent was upheld for the reason that the patentee had created something that had never existed before.

"It appears that calcium carbide under different conditions takes both the crystalline and the amorphous forms. The specification itself states, as we have seen, that the substance had existed in an amorphous form prior to the invention, and *the patent relates solely to the crystalline form* * * *" (Emphasis ours.)

That was also true in the case of *J. E. Baker Company v. Kennedy Refractories Company et al.* (C. C. A. 3), 253 Fed. 739, 741, relied upon by the Circuit Court.

"* * * By the apparently simple expedient of double burning, *the patentee got a product chemically and commercially unlike any dolomite product theretofore known*, which the metallurgical art, notwithstanding the predominating lime base of the product, accepted at once as the equal of and a fair substitute for Austrian magnesite with its magnesia base. * * *" (Emphasis ours.)

In *General Electric Co. v. DeForest Radio Co. et al.* (C. C. A. 3), 28 Fed. (2d) 641, 643, the question was whether a natural element "tungsten" could be the subject of a patent. In holding the patent invalid the Court stated:

> "Naturally we inquire who created pure tungsten. Coolidge? No. It existed in nature and doubtless has existed there for centuries. The fact that no one before Coolidge found it there does not negative its origin or existence. * * *
>
> "* * * it is now conceded that tungsten pure is ductile cold. If it possesses that quality now it is certain that it possessed it always. Therefore the second part of the claim is merely a correct description of the first part and the first part broadly claims as an invention a product of nature in the form of a chemical element for which a product claim as distinguished from a process claim cannot be validly awarded."

Bond admits that he makes no change in the natural inherent characteristics and functioning of the bacteria. (R. 116.) Therefore he had made no patentable invention.

Even assuming Bond's discovery to be new, the Court, in *Universal Winding Co. v. Foster Machine Company*, 16 F. Supp. 671, 677 (D. C. Mass.), affirmed (C. C. A. 1) 90 F. (2d) 472, stated:

> "* * * The discovery that a law of nature will produce a desired result, apart from any novelty in the means by which that law is brought into operation, is not patentable. *Magin v. Karle*, 150 U. S. 387, 392, 14 S. Ct. 153, 37 L. Ed. 1118; *Knapp v. Morss*, 150 U. S. 221, 228, 14 S. Ct. 81, 37 L. Ed. 1059. See, also, *Risdon Iron & Locomotive Works v. Medart*, 158 U. S. 68, 15 S. Ct. 745, 39 L. Ed. 899."

Bond does not go beyond "mere domain of discovery." He merely selects the best of the bacteria that he can find in nature by a series of old test selections and segregates those that most beneficially perform their natural function of fixing nitrogen in the leguminous plants and includes them in his composite inoculant.

Novocol Chemical Manufacturing Co., Inc. v. Powers & Anderson Dental Company (C. C. A. 4), 128 F. (2d) 904, 907:

> "There was no invention in conducting routine tests to prove or disprove the existence of a physical fact. Patents may be issued for arts, machines, manufactures and compositions of matter, 35 U. S. C. A. § 31. But the laws of nature and their workings are not the subject of invention by man. He may discover them and bring them to the knowledge of the world but he cannot patent that discovery; he can obtain a patent only when he has invented an art or a machine whereby to utilize his discovery. *O'Reilly v. Morse* (involving invention of the telegraph) 15 How. 62, 112; 14 L. Ed. 601; *Walker on Patents*, 6th Ed., Sect. 18."

The Subject of the Bond Patent is Not Within the Classifications of R. S. 4886.

Regardless of whether the alleged discovery of Bond is new, the subject of the Bond Patent is not an art, machine, manufacture or composition of matter within the purview of the statute.

Admittedly the subject of the Bond Patent is not an art, or a machine. Neither is it a manufacture as defined by this Court in *American Fruit Growers, Inc. v. Brogdex Company*, 283 U. S. 1, 11, 51 S. Ct., 328, 75 L. Ed., 801 for there the court said:

> "'Manufacture,' as well defined by the Century Dictionary is 'the production of articles for use from raw or prepared materials by giving to these materials new forms, qualities, properties, or combinations, whether by hand-labor or by machinery.' Also 'anything made for use from raw or prepared materials.'".

Further, the subject of the Bond Patent is not a true composition of matter for each species of bacteria in the inoculant of the patent work by their own law of nature completely independently of any other species in the inoculant, just as though it were not there. In a true com-

position of matter each element loses its identity to give properties to the composition the individual elements do not possess, as stated in *P. E. Sharpless Co. v. Crawford Farms*, 287 Fed. 655, 658 (C. C. A. 2):

> "* * * A patentable composition of matter may well result or be formed by the intermixture of two or more ingredients, which develop a different or additional property or properties which the several ingredients individually do not possess in common. * * *"

II. CAN THE DISCOVERIES OF THE LAWS OF NATURE AND OF NATURAL PRODUCTS, WITHOUT FURTHER CONTRIBUTION BY THE DISCOVERER, BE THE SUBJECT OF PATENT MONOPOLY UNDER THE PATENT STATUTE R. S. 4886, OR DO THEY BELONG TO THE PUBLIC?

The Circuit Court of Appeals based its decision on the finding of the District Court that Bond "discovered the fact that among the bacteria found widely spread in nature there existed both mutually inhibitive and mutually non-inhibitive strains which can be selected and isolated and when so selected and isolated perform the same function that they do in nature." (Finding 12, R. 749.) The Circuit Court went on to say that on the basis of this teaching they thought that Bond had made an invention.[36]

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[36] Quotations from Decision of Circuit Court:

"His teaching was that he could, by conventional tests, delete the inhibitive strains and retain the non-inhibitive ones and that these, when combined, could be put into a composite inoculant where the same desirable results could be achieved by each appropriate species of bacteria as would be accomplished if only a single species of bacteria were included in the inoculant. *Upon this we think the question of invention hinges.* * * *" (R. 820.) (Emphasis ours.)

"* * * However, he [District Court] made a specific finding that Bond did discover that there exist in nature non-inhibitive strains and that these non-inhibitive strains may be selected, isolated and combined and still perform satisfactorily

(Continued on following page)

When the Circuit Court in the critical statement of its decision held

> "* * * the discovery of a natural phenomenon or of a quality or attribute of a well known article and application of that quality in a successful combination which is of value to mankind, is entitled to patent protection."

it raised a fundamental question as to the interpretation of R. S. 4886 as applied to the patentability of a discovery of a phenomenon of nature or elements of nature, when the discoverer does nothing but use the natural phenomenon or element in its natural form for the purpose it performs in nature, in the same old way.

This statement of the Circuit Court of Appeals does not take into account the fact that the Patent Statute (R. S. 4886) requires that an invention or discovery shall be "new" as well as "useful." It makes no difference how useful a device or a product may be, or how revolutionary its character may be, *if it is not new* as well as useful it fails to meet the patent statute. This Court has said in *Cuno Engineering Corporation v. Automatic Devices Corporation*, 314 U. S. 84, 90, 62 S. Ct. 37, 86 L. Ed. 58:

> "* * * Under the statute (35 U. S. C. § 31; R. S. § 4886) the device must not only be 'new and useful,' it must also be an 'invention' or 'discovery.' *Thompson v. Boisselier*, 114 U. S. 1, 11. * * *"

The corollary of this is, to make a device patentable it must not only be an invention or a discovery, it must be "*new*" and useful. That which has existed as a funda-

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(*Continued from preceding page*)

their ordinary desirable functions. Upon this finding there was controverted evidence, but our examination of the record is convincing that that supporting the findin ; is rather conclusive and that there is no justification for us to declare the District Court in error in making it. Consequently the specific question which now confronts us is whether, upon the finding of fact, the court erred in concluding that, under the law, Bond made nothing patentable." (R. 820.)

mental law of nature in the storehouse of knowledge yet undiscovered, but which existed from time immemorial, is not "new."

The bacteria, either as inhibitive or non-inhibitive kind, have existed in nature and have acted according to their own law of nature long before any invention of Bond. His only contribution is in discovering, if it was a discovery, the existence of the legume bacteria, which, acting according to their law of nature, will not be inhibited by another when placed in association in a humus base or carrier.

Bearing in mind that mixed inoculants "*per se*" were not new at the time of the Bond invention, and that all that Bond did was to discover by conventional tests of the existence in nature of both inhibitive and non-inhibitive bacteria, the mistake of the Circuit Court lay, we think, in attributing to the "discovery" the status of invention within the meaning of the Patent Statute (R. S. 4886).

Even assuming that Bond was the first to make a "commercially successful" mixed inoculant, a thing may be new in the sense that it is placed on the market for the first time, but that does not make it new in the patentable sense. This, we think, is where the Circuit Court incorrectly applied the alleged newness of the Bond discovery. Mr. Justice Clifford, in *Collar Co. v. Van Dusen*, 23 Wall. 530, 563, 23 L. Ed. 128, clearly set forth this distinction when he said:

> "Articles of manufacture may be new in the commercial sense when they are not new in the sense of the patent law. New articles of commerce are not patentable as new manufactures, unless it appears in the given case that the production of the new article involved the exercise of invention or discovery beyond what was necessary to construct the apparatus for its manufacture or production."*

"* *Glue Company v. Upton*, 6 Official Gazette, 840."

"Nothing short of invention or discovery will support a patent for a manufacture any more than for an art, machine, or composition of matter, for which proposition there is abundant authority in the decisions of this Court.†"

"† *Hotchkiss v. Greenwood*, 11 How. 265, *Phillips v. Page*, 24 How. 167; *Jones v. Morehead*, 1 Wall. 162; *Stimpson v. Woodman*, 10 Wall. 121.

See also:

Dunbar v. Meyers, 94 U. S. 187, 196, 197, 24 L. Ed. 34; *Roemer v. Simon*, 95 U. S. 214, 217, 218, 24 L. Ed. 384."

In *Boston Pencil Pointer Co. v. Automatic Pencil Sharpener Co.* (C. C. A. 2) 276 Fed. 910, 912, the Court said:

"Further, it is settled that articles may be new in a commercial sense, when they are not new in the sense of the patent law (*Collar Co. v. Van Dusen*, 23 Wall. 530, 23 L. Ed. 128), and novelty, however great, can never be put in the place of invention (*Robins v. Link Belt*, 233 Fed. 1005, 148 C. C. A. 15). * * *"

Hence, novelty, utility or commercial success alone will not sustain invention. There must be invention to begin with.

This Court, in *Mackay Radio & Telegraph Co. v. Radio Corporation of America*, 306 U. S. 86, 94, 59 S. Ct. 427, 83 L. Ed. 506, said:

"While a scientific truth, or the mathematical expression of it, is not patentable invention, a *novel* and useful *structure* created with the aid of knowledge of scientific truth may be. * * *" (Emphasis ours.)

We would here call the attention of this Court to the fact that only a "novel structure" created by the patentee with the aid of a scientific truth, is patentable. Bond does not create a "novel structure," for the mixed inoculant was known before him. The bacteria used by Bond are no different from those found in nature or from those which could, may or did exist in the prior mixed inoculants. The base of the inoculant is no different nor is there any differ-

ence in the creation of the large numbers of the bacteria for incorporation in the base.

The only contribution of Bond is that of a scientific discovery by which he determines the natural functioning of the bacteria and then, without any change, he uses the non-inhibitive kind of bacteria.

It should be noted that the attribute of invention is given by the Circuit Court to the discovery of a natural phenomenon without regard to whether there is a "new" structure created by the patentee. The "newness," if any, is in the discovery of the natural phenomenon, not in the product, for mixed inoculants were old at the time of the Bond patent.

Thus, the Circuit Court places the attribute of invention upon its "value to mankind." R. S. 4886 requires that there be a "new and useful art, machine, manufacture or composition of matter" before a patent be awarded to an inventor.

This decision of the Circuit Court of Appeals would avoid the requirement of the patent statute and would put in its place the rule that a discovery of a natural phenomenon applied to a successful combination which is of value to mankind, establishes invention. *This, we think, is a matter for Congress to decide.*

III. AN OLD PRODUCT OR PRODUCTS OF NATURE IN COMBINATION CANNOT BE PATENTED BY A MERE DISCOVERY OF A NEW QUALITY EXISTING IN NATURE. UNDER SEC. R. S. 4886 A COMBINATION TO BE PATENTABLE MUST BE BOTH NEW AND USEFUL AND BASED UPON A CONTRIBUTION TO THE PUBLIC NOT EXISTING IN NATURE.

Bond does not dispute the fact that before his invention mixed inoculants were known and used for inoculating leguminous plants of a plurality of cross-inoculation groups. Neither will he dispute the fact that when these prior mixed inoculants were used they effected the desired result of inoculating the various leguminous plants on which they were intended to be used and that nitrogen was fixed by the plants. His only disagreement with the prior art is that the prior mixed inoculants did not work as efficiently as they might have.

Bond cannot dispute the fact that before his patent legume bacteria that were highly efficient in their ability to fix nitrogen in the leguminous plants were known and used by many manufacturers.[37]

In the case before us, the mixed inoculant "*per se*" is not new, no new kind of bacteria have been discovered that did not exist in nature before the Bond patent, no new method of propagating the bacteria is disclosed, no new humus base is used, nor is there any new method of putting the bacteria in the humus base disclosed in the Bond patent. All of these were well known before the Bond patent and the only thing that Bond contributed to the art, if anything, is the idea of using non-inhibitive strains of bacteria in a mixed inoculant of the same kind known previously in the prior art.

Now, it may very well be that by using only non-inhibitive strains of bacteria in an inoculant instead of some strains that might be inhibitive, a commercial product

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[37] See footnote 34, page 20.

is produced that is better to a degree than those of the prior art, but this does not result from any new mechanical arrangement of the elements of the composition, but from the fact that the material of which the inoculant is composed happens to be better adapted to the purpose for which it was made. Any improvement therefore is in the use of the superior strains of bacteria, which "*per se*" are not new, having existed in nature from time immemorial. But as this Court said in *Hotchkiss v. Greenwood*, 11 How. 248, 266; 13 L. Ed. 683:

> "But this, of itself, can never be the subject of a patent. No one will pretend that a machine made, in whole or in part, of materials better adapted to the purpose for which it is used than the materials of which the old one is constructed, and for that reason better and cheaper, can be distinguished from the old one, or, in the sense of the patent law, can entitle the manufacturer to a patent."

Each strain of bacteria performs, in the mixed inoculant, exactly the same function that it produces in nature unlimited, unchanged, unmodified in any way by the Bond patent. "Each served as separately it had done." *Toledo Pressed Steel Co. v. Standard Parts, Inc.*, 307 U. S. 350, 356, 59 S. Ct. 897, 83 L. Ed. 1334.

Bond in his patent has simply set forth an old testing technique which is useful in the manufacture of mixed inoculants under modern methods. That technique involves the act of selecting non-inhibitive from inhibitive bacteria and then using the bacteria in the mixed inoculant to allow them to produce their normal, natural function in the same way in which they do in nature. Even assuming that Bond is the first to discover the non-inhibitive bacteria, "the law does not protect the act of selection *per se*, however meritorious, when it is not materially incorporated into some new physical object." *Old Town Ribbon & Carbon Company, Inc. v. Columbia Ribbon and Carbon Mfg. Co.* (C. C. A. 2), 159 F. (2d) 379, 382.

Bond's physical object, the mixed inoculant, was not new "*per se.*" Bond had an idea, but an idea of itself is not patentable. The idea might have been a good one, "but his device, to give it effect, though useful, was not new." *Rubber Tip Pencil Company v. Howard*, 20 Wall. (87 U. S.) 498, 507, 22 L. Ed. 410. In *DeForest Radio Co. v. General Electric Co.*, 283 U. S. 664, 684, 685, 51 S. Ct. 563, 75 L. Ed. 1339, this Court stated:

> "• • • It is method and device which may be patented and not the scientific explanation of their operation. See *LeRoy v. Tatham*, 14 How. 156, 174-6."

However skillfully Bond brought the non-inhibitive bacteria together, and even though there was produced a commercial inoculant that was more efficient than the commercial inoculants of the prior art, "it was still the product of skill, not of invention." *Altoona Public Theatres, Inc. v. American Tri-Ergon Corp. et al.*, 294 U. S. 477, 486, 55 S. Ct. 455, 79 L. Ed. 1005.

The non-inhibitive strains of bacteria, which Bond says he discovered exist in nature, have functioned according to their law of nature from long before the Bond patent with the inevitable result of fixing nitrogen in the leguminous plants.

When these bacteria are placed in a mixed inoculant, and Bond admits that they could have been placed in the mixed inoculants of the prior art (R. 133), they would produce their inevitable result of fixing nitrogen according to their own law of nature, and nothing that Bond has done in his patent in any way changes this fact. "If the asserted result was inevitable in the method of the patents, it was inevitable in the method in use prior to the patents, • • •" *Foley, Admx. of Gathmann v. U. S.*, 260 U. S. 667, 676, 677, 43 S. Ct. 240, 67 L. Ed. 451.

Vitamin Technologists Case.

The alleged invention of the Bond patent is an exact parallel to the facts in the case of *Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation*, 146 F. (2d) 941, C. C. A. 9.

In the *Vitamin Technologists* case, Steenbock discovered that ultra-violet rays could irradiate foods with Vitamin D. While this was a new discovery of Steenbock, yet it was a condition that was occurring in nature and had occurred "from time immemorial by the farmer in hay-curing in the sun and the coconut grower sun-drying the cut meat of the coconut." (p. 949.) Steenbock had discovered the result of the effect of a natural law, which to him was new, but which to nature was old.

The Circuit Court, in the *Vitamin Technologists* case, saw clearly the distinction between a patent on an effect of the use of a law of nature and a patent on a law of nature. Steenbock's patent was not a patent on a law of nature "*per se*," but was a patent on the effect of the operation of a law of nature as found in an irradiated food product. So, there, the Court held that Steenbock did not "seek a monopoly of the ultra-violet rays of the sun or lamp, a natural force, * * *" (p. 949) but that Steenbock could not patent the effect produced by the ultra-violet rays of the sun or of a lamp, as that effect had been produced by these rays from time immemorial.

Steenbock's analytical mind recognized the true meaning of the effect of the application of ultra-violet rays to food products. But, recognition of a scientific truth so as to put one in a position to be able to utilize that scientific truth, is not invention. Invention can only be found in the production of a new, previously non-existing device, product or composition of matter. *LeRoy v. Tatham*, 14 How. 156, *supra; Morton v. New York Eye Infirmary*, 17 Fed. Cas. 881, *supra.*

His Honor, Judge Healy, in a concurring opinion in the *Vitamin Technologists* case, went even further to state that

Steenbock's discovery "would amount to no more than the ascertainment of a naked fact or principle in nature existing independently of the efforts of the discoverer."[38]

So in this case, assuming that Bond made a new discovery of the non-inhibitive characteristic of certain strains of the legume bacteria, he did no more than ascertain "a naked fact or principle in nature existing independently of the efforts of the discoverer." **If the bacteria did not function in exactly their natural way, Bond would have no product. He depends upon the law of nature to cause the bacteria to perform in their natural way and nothing that he does in any way affects their natural functioning. This functioning is completely independent of any effort of the patentee Bond, and he admits this fact.**[39]

The bacteria of the non-inhibitive kind have always existed in nature just like the actinic rays of the sun have always existed in nature. The bacteria have always produced their natural function of fixing nitrogen in the legume plants anywhere they could infect the roots of the legume plants just like the actinic rays of the sun have always irradiated the sun-cured hay and coconut meat.

It was stated in the *Vitamin Technologists* case to be absurd to entertain the proposition "that because the farmer and copra grower did not know the photochemical process involved in their immemorial practice, they may be enjoined as infringers." (p. 948, *Vitamin Technologists.*) So here, it would be absurd to entertain the proposition that because the producers of prior mixed inoculants did not know that they had both inhibitive and non-inhibitive strains of bacteria in their mixed inoculants, they may now be enjoined as infringers.

The most that can be said of the Bond patent is that it discloses an act or series of acts of selection, and as we have previously stated "the law does not protect the act

[38] See Appendix page 48.

[39] Testimony—R. 125.

of selection *per se*, however meritorious * * *." *Old Town Ribbon & Carbon Co. Inc. v. Columbia Ribbon and Carbon Mfg. Co.*, 159 F. (2d) 379, 382. (C. C. A. 2.)

IV. A PRODUCT CLAIM THAT RELIES FOR ITS NOVELTY UPON A STATEMENT OF FUNCTION IS INVALID.

Even if Bond was the first to discover the non-inhibitive bacteria, his discovery is not patentable for he makes the use or function of the result of the action of the bacteria the measure or test of the choice of the ingredients of the inoculant.

Bond admits in his patent that there is no way by which one can determine whether a strain of bacteria is inhibitive or not except by testing the strains of bacteria on their host plant, and thus makes selective testing a requirement to determine infringement or non-infringement by a mixed inoculant product.

This Court has held that no inventor may compel independent experimentation by others to ascertain the bounds of his claims. *Standard Brands, Inc. v. National Grain Yeast Corporation*, 308 U. S. 34, 60 S. Ct. 27, 84 L. Ed. 17.

Every element of the language of the claims of the Bond patent is old. Only by terms of function as to the result of the natural action of the bacteria do the Bond claims make any distinction from the prior art. The language of the claims is clearly within the condemnation of this Court as to the use of functional language at the exact point of alleged novelty in the claims, this Court stating in *Halliburton Oil Well Cementing Co. v. Walker et al.*, 329 U. S. 1, 9, 67 S. Ct. 6, 91 L. Ed. 15:

> "* * * The language of the claim thus describes this most crucial element in the 'new' combination in terms of what it will do rather than in terms of its own physical characteristics or its arrangement in the new combination apparatus. We have held that a claim with such a description of a product is invalid as a

violation of Rev. Stat. 4888. *Holland Furniture Co. v. Perkins Glue Co.*, 277 U. S. 245, 256-57; *General Electric Co. v. Wabash Appliance Corp., supra.* [304 U. S. 364]. * * *"

In the *General Electric* case, 304 U. S., 364, 58 S. Ct. 899, 82 L. Ed. 1402, this Court said:

"* * * But the vice of a functional claim exists not only when a claim is 'wholly' functional, if that is ever true, but also when the inventor is painstaking when he recites what has already been seen, **and then uses conveniently functional language at the exact point of novelty.**[11]" (p. 371.) (Emphasis ours.)

"[11] See *Gynex Corp. v. Dilex Institute*, 85 F. (2d) 103, 105; *Davis Co. v. New Departure Co.*, 217 F. 775, 782."

Here, there is no limiting of the Bond claims by the recitation of the non-inhibitive character of the bacteria for the functional language of the claims includes bacteria that not only do not inhibit one another under the Bond patent, but to the contrary, may have a beneficial effect on one another. The latter is within the scope of the language of the Bond claims as well as the former.

This, we think, is beyond the scope of the alleged Bond invention and is beyond the scope of any discovery of his.

Patentability of a Claim Involving a Mental Operation.

Bond's invention to be practiced requires a mental determination of whether you have inhibitive or non-inhibitive bacteria as a result of scientific tests and calculations. Where a claim involves mental steps as its essence, the claim is invalid. Not only is such a claim not an invention within the scope of the statute, because it is indefinite, but like its companion use of scientific principles and laws of nature, it does not fall within the classification of an art, a machine, an article of manufacture or a composition of matter.

In *Halliburton Oil Well Cementing Co. v. Walker*, 329 U. S. 1, 67 S. Ct. 6, 91 L. Ed. 15, a process claim that required intellectual operations necessary to interpret the data recorded, was held invalid. In this case the claims for the process likewise require a mental step of mathematical calculations, analysis and comparison of the tests to determine non-inhibitory characteristics of the bacteria, just as in the *Halliburton* case, to determine the depth of the well it was necessary to create an acoustical impulse, record the echo and then take the mental step of a mathematical calculation to determine well depth.

In both cases the practical difficulty arises of being able to tell how anyone performs the mental steps, and he is an infringer if he does. The public is entitled to certainty in a patent. But passing that problem, it is obvious that the mental step is another form of the law of nature which no patent claim can monopolize. In *Don Lee, Inc. v. Walker*, 61 F. (2) 58 (C. C. A. 9), a claim was directed to a method of computing the quantum, and also of counterbalances on Crankshafts by a mathematical formula. It was held invalid. This has been the position, as we understand it, on the law by the Courts.

The claims in this case, where they rely upon tests to determine what is inhibitory and non-inhibitory, are invalid because they fail to make the "full, clear, concise and exact" description of the alleged invention required by R. S. 4888.[40] How can one tell whether he has acquired a non-inhibitory strain? What rule in the claim or patent tells him when he has made an infringing intellectual determination, or when he has not? Likewise, the instant claims run afoul of R. S. 4888 because they do not describe the invention with precision, but use "conveniently functional language at the exact point of novelty." *General Electric Co. v. Wabash Appliance Corp.*, 304 U. S. 364, 371, 58 S. Ct.

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[40] See Appendix page 44.

899, 82 L. Ed. 1402. *Holland Furniture Co. v. Perkins Glue Co.*, 277 U. S. 245, 256-57, 48 S. Ct. 474, 72 L. Ed. 868.

In the *Halliburton* case there was no indication that the patentee contemplated any specific structural alteration in the electrical application, just as in this case there is no alteration in the bacteria or the humus in which the bacteria function. In both cases the law of nature of acoustical calculations and sound reactions and bacteriological action are unmodified by any contribution of the patentees. In both cases they have attempted to monopolize functionally indefinite mental processes never contemplated by patent law and excluded by its statutes.[41]

Non-Patentability of Therapeutic Methods.

As a further indication of the long policy of the Courts, it has been traditional in the Patent Office for more than sixty years to refuse patents, except in rare cases, relating to the medical treatment of the human body. The leading case in the Patent Office is the *Brinkerhoff* decision of 1883. (*Ex parte Brinkerhoff*, Commissioner's Manuscript Decision, Vol. 24, page 349, Case No. 132; 27 J. P. O. S. 797.) The methods and modes of treatments by physicians of diseases are not patentable because such discoveries or methods of treatment under all circumstances, and in all cases, will not produce upon all persons the same results. The laws of nature and intellectual ability of the physician render the matter unpatentable and too uncertain and indefinite to be subject to monopoly by definition.

Such claims are rejected because they do not meet the definition of an art or composition of matter. *Cochrane v. Deener*, 94 U. S. 780, 24 L. Ed. 139, defined an art as "An Act or series of acts performed upon a definite subject matter for the purpose of reducing it to a different state."

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[41] See discussion *George Washington Law Review*, June 1945, Vol. 13, No. 4, pages 498-499.

So it was that the Court in *Morton v. New York Eye Infirmary*, Fed. Case 9865, 17 Fed. Cas. 881 refused to sustain the patent for the use of ether as an anaesthetic. So it was in *Ex parte Mills*, 366 O. G. 477, the Examiner and Board of Appeals in the Patent Office holding that "the claims define nothing classifiable within either of the classes of patentable inventions." When Mills tried to patent the coagulative agent in blood, termed fibrinogen, he merely attempted to take advantage of a law of nature of this material without doing more. The Patent Office has followed almost universally the *Brinkerhoff* and *Morton* cases; and the Courts likewise proceed with great care in this area where the practice of an art is not the creation of the art.

V. PUBLIC IMPORTANCE.

In view of the vast increase in basic research in the use of bacteria in the field of medicine and industrial products as well as in the field of agriculture, the correctness and soundness of the decision of the Circuit Court of Appeals for the Seventh Circuit and the assertion of patent rights under it is of great moment to the public.

Unless the basic issue raised here is now settled by this Court, the decision of the Circuit Court of Appeals for the Seventh Circuit will cause judicial controversy for years to come regardless of the fact that the patent statute R. S. 4886 does not provide for patent protection on mere discoveries.

The possession and assertion of patent rights are "issues of great moment to the public." *Hazel-Atlas Glass Co. v. Hartford-Empire Co.*, 322 U. S. 238, 246, 64 S. Ct. 997, 88 L. Ed. 1250. See also *Mercoid Corp. v. Mid-Continent Investment Co.*, 320 U. S. 661, 665, 64 S. Ct. 268, 88 L. Ed. 376; *Morton Salt Co. v. Suppiger Co.*, 314 U. S. 488, 62 S. Ct. 402, 86 L. Ed. 363; *United States v. Masonite Corp.*, 316 U. S. 265, 278, 62 S. Ct. 1070, 86 L. Ed. 1461.

The far-reaching social and economic consequences of a patent, therefore, give the public a paramount interest **in seeing that patent monopolies are kept within their legitimate scope.** *Precision Instrument Manufacturing Co. et al. v. Automotive Maintenance Machinery Co.*, 324 U. S. 806, 816, 65 S. Ct. 993, 89 L. Ed. 1381.

In an age when our nation's security, our prosperity and our lives are dependent upon the free use of scientific discoveries as a part of the public domain, the paramount public interest demands that there be no private monopoly of such results of scientific discovery. "Discovery" and "invention" as used by the Statute clearly are limited to "new and useful art, machine, manufacture, or composition of matter" into which classifications scientific discoveries do not fall. The Statute is designed to reward man-made creation of something that never existed before.

To try to justify such monopoly on the ground that the discovery of the scientific law was "new" simply begs the question. "Discovery" and "invention" as defined by the Statute is that which the inventor creates for the public benefit *which never existed before,*—it does not apply to those things that have long existed as the laws of our existence, but which are newly revealed to us by diligent search of a scientist.

Respectfully submitted,

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APPENDIX A.

Pertinent Statutes.

R. S. 4886, 35 U. S. C. A. § 31:

Any person who has invented or discovered any new and useful art, machine, manuf cture, or composition of matter, or any new and useful improvements thereof, or who has invented or discovered and asexually reproduced any distinct and new variety of plant, other than a tuber-propagated plant, not known or used by others in this country, before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, or more than one year prior to his application, and not in public use or on sale in this country for more than one year prior to his application, unless the same is proved to have been abandoned, may, upon payment of the fees required by law, and other due proceeding had, obtain a patent therefor. R. S. § 4886; March 3, 1897, c. 391, § 1, 29 Stat. 692; May 23, 1930; c. 312, § 1, 46 Stat. 376; Aug. 5, 1939, c. 450, § 1, 53 Stat. 1212.

R. S. 4888, 35 U. S. C. A. § 33:

Before any inventor or discoverer shall receive a patent for his invention or discovery he shall make application therefor, in writing, to the Commissioner of Patents, and shall file in the Patent Office a written description of the same, and of the manner and process of making, constructing, compounding, and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art or science, to which it appertains, or with which it is most nearly connected, to make, construct, compound, and use the same; and in case of a machine, he shall explain the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions; and he shall partic-

ularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery. The specification and claim shall be signed by the inventor. No plant patent shall be declared invalid on the ground of noncompliance with this section if the description is made as complete as is reasonably possible. R. S. § 4888; March 3, 1915, c. 94, § 1, 38 Stat. 958; May 23, 1930, c. 312, § 2, 46 Stat. 376.

APPENDIX B.

Bond Claims in Suit.

1. An inoculant for leguminous plants comprising plurality of selected cultures of different species of bacteri of the genus Rhizobium, one of said cultures being *Rhizobium trifolii alpha*, said cultures being substantially un affected by each other in respect to their ability to fi nitrogen in the leguminous plant for which they are specific

3. An inoculant for leguminous plants comprising humus and a mixture of species of bacteria of the genu Rhizobium, said mixture containing a strain of *Rhizobium trifolii alpha*.

4. An inoculant for leguminous plants comprising plurality of selected mutually non-inhibitive strains o different species of bacteria of the genus Rhizobium, sai strains being unaffected by each other in respect to thei ability to fix nitrogen in the leguminous plant for which the are specific.

5. An inoculant for leguminous plants comprising plurality of strains of different species of bacteria of th genus Rhizobium, at least one of which strains is un affected by the others in respect to its ability to fix nitroge in the leguminous plant for which it is specific.

6. An inoculant for leguminous plants comprising plurality of strains of different species of bacteria of th genus Rhizobium, the bacteria of each strain being presen in numbers of substantially the same order of magnitude said strains being substantially unaffected by each other i respect to their ability to fix nitrogen in the leguminou plant for which they are specific.

7. A bacterial inoculant for leguminous plants com prising a moist powder base and a plurality of selected mutually non-inhibitive strains of different species of bac teria of the genus Rhizobium including *Rhizobium tri folii*, the bacteria of each strain being present in number

of substantially the same order of magnitude, said strains being substantially unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific.

8. A bacterial inoculant for leguminous plants comprising a moist powder base containing a substantially negligible concentration of bacterial nutrients and a plurality of strains of different species of bacteria of the genus Rhizobium, at least one of which strains is unaffected by the others in respect to its ability to fix nitrogen in the leguminous plant for which it is specific.

13. A bacterial inoculant for leguminous plants comprising a plurality of strains of different species of bacteria of the genus Rhizobium in numbers of substantially the same order of magnitude incorporated with a powder base, the mixture being substantially free of bacterial nutrients whereby growth of the bacteria therein is inhibited.

14. The inoculant as defined in claim 13 wherein one of said species is *Rhizobium trifolii*.

APPENDIX C.

Excerpt From Judge Healy's Concurring Opinion in Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation, 146 F. (2d) 941, 954 (C. C. A. 9).

I think the Steenbock patents are subject to an infirmity still more fundamental. Ultra-violet light is a natural form of energy. Like the sun, which is the source of that energy, and like the air we breathe, ultra-violet rays are the property of all mankind. Man may devise or improve machines for their more effective utilization and may obtain patents upon the machine or the improvement. But it would be a monstrous thing if the energy itself could be made the subject of a monopoly. It must be remembered that sunlight by its own inherent process activates the vitamin D principle in both inert and living tissues and substances, albeit, because of unfavorable atmospheric conditions, sunlight is not effective in all cases. Nevertheless it is clear that the artificial process differs in no essential particular from the natural one. The intervention of the mercury vapor lamp—developed long prior to Steenbock—may adapt the natural process to wider fields, but in a patentable sense the process itself is as ancient as the sun.

It seems to me doubtful that the claims should be held invalid because lacking in particularity in respect of the period of time of exposure. It may be that they are sufficiently specific to enable those skilled in the art to understand what is intended. I assume, therefore, that Steenbock discovered and sufficiently disclosed in his claims the most effective time period of exposure. Nevertheless such a discovery would not amount to a patentable invention. It would amount to no more than the ascertainment of a naked fact or principle in nature existing independently of the efforts of the discoverer. Cf. *O'Reilly v. Morse*, 15 How. 62, 14 L. Ed. 601; *Tilghman v. Proctor*, 102 U. S. 707, 722-729, 26 L. Ed. 279. If the discovery were patentable, it would be broader than the process itself in that it "would

over all processes which aim at the same result,"[1] including even the purposeful exposure of dietary substances to the direct rays of the sun.

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[1] *Walker on Patents*, Deller's Ed., Vol. 1, p. 65.

In the Supreme Court of the United States

OCTOBER TERM, A. D. 1947.

No. 280.

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

REPLY BRIEF FOR PETITIONER.

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INDEX.

I. There Are No Concurrent Findings of the Courts Below 1

II. Petitioner Has Made No Confession of No Anticipation 2

III. Mixed Inoculants Are Old 2

IV. Bond Had No New Composition of Matter and Attempts to Incorporate Limitations By Inference 3

V. Bond's Claims Are Not Limited to Critical Factors Set Forth In Respondent's Brief 5

VI. Respondent Admits Mixed Inoculants Are Old.. 6

VII. Mere Discovery of Law of Nature Is Not Invention 7

VIII. Bond's Inoculant Is Not A True Composition of Matter 9

IX. Petitioner Need Not Rely On Invalidity By Reason of Anticipation for Bond Has No Invention 11

X. Novelty and Utility are Insufficient to Support Invention 12

XI. Discovery of a New Use of a Law of Nature, Without More, Is Not Invention 14

XII. Commercial Success Alone Does Not Support Invention 15

XIII. Functional Language in the Claims Is Improper When Other Language Is Available 16

XIV. Respondent's Statement of Petitioner's Position Is Incorrect 17

XV. Specific Answers to Respondent's Brief 17

XVI. Public Importance 21

TABLE OF AUTHORITIES.

Cases.

Cameron Septic Tank Co. v. Village of Saratoga Springs (C. C. A. 2), 159 Fed. 453, c. d. 209 U. S. 548, 28 S. Ct. 759, 52 L. Ed. 921 18

Collar Co. v. Van Dusen, 23 Wall. (90 U. S.) 530, 23 L. Ed. 128 ..... 2, 3

Cuno Engineering Corporation v. Automatic Devices Corporation, 314 U. S. 84, 62 S. Ct. 37, 86 L. Ed. 58 ..... 8, 13

Dow Chemical Co. v. Halliburton Oil Well Cementing Co., (C. C. A. 6, 1943), 139 F. (2d) 473, affirmed (1945) 324 U. S. 320, 65 S. Ct. 647, 89 L. Ed. 973... 15

Dunbar v. Meyers, 94 U. S. 187, 24 L. Ed. 34 3

Ewald, In re (C. C. P. A., 1941), 117 F. (2d) 755..... 16

Foley, Admx. of Gathmann v. United States, 260 U. S. 667, 43 S. Ct. 240, 67 L. Ed. 451 22

General Electric Co. v. DeForest Radio (C. C. A. 3), 28 F. (2d) 641, c. d. 278 U. S. 656, 49 S. Ct. 180, 73 L. Ed. 565 19

General Electric Co. v. Wabash Appliance Corp. et al., 304 U. S. 364, 58 S. Ct. 899, 82 L. Ed. 1402 16

Gerald M. Friend, Inc. v. Walsh et al. (C. C. A. 2, 1944), 141 F. (2d) 180 15

Halliburton Oil Well Cementing Co. v. Walker et al., 329 U. S. 1, 67 S. Ct. 691, 91 L. Ed. 15 ..... 7, 14, 16

Hegan, In re (C. C. P. A., 1938), 97 F. (2d) 86..... 16

Hotchkiss v. Greenwood, 11 How. (52 U. S.) 248, 13 L. Ed. 683 7

Kissock v. Duquesne Steel Foundry Co. et al. (C. C. A. 3, 1929), 37 F. (2d) 249, c. d. 281 U. S. 749, 50 S. Ct. 354, 74 L. Ed. 1161 15

LeRoy et al. v. Tatham, et al., 14 How. (55 U. S.) 156, 14 L. Ed. 367 ..... 7, 13, 17, 18

Libby-Owens-Ford Glass Co. v. Celanese Corporation, 135 F. (2d) 138 10

Mackay Radio & Telegraph Co. v. Radio Corporation of America, 306 U. S. 86, 59 S. Ct. 427, 83 L. Ed. 506 ..... 8, 13, 19

Metals Recovery Co. v. Anaconda Copper Mining Co., 31 F. (2d) 100 10

Old Town Ribbon & Carbon Co. v. Columbia Ribbon & Carbon Mfg. Co., 159 F. (2d) 379 7

Pickering v. McCullough, 104 U. S. 310, 26 L. Ed. 749 .. 11

Roemer v. Simon, 95 U. S. 214, 24 L. Ed. 384 3

Sewall v. Jones, 91 U. S. 171, 23 L. Ed. 275 18

Smith v. Hall, 301 U. S. 216, 232, 57 S. Ct. 711, 81 L. Ed. 1049 ..... 5, 6, 21

Telephone Cases, 126 U. S. 1, 8 S. Ct. 778, 31 L. Ed. 863 15

Univis Corporation et al. v. Rips et al. (C. C. A. 6, 1939), 104 F. (2d) 749, c. d. 308 U. S. 592, 60 S. Ct. 121, 84 L. Ed. 495 15

White v. Dunbar, 119 U. S. 47, 7 S. Ct. 72, 30 L. Ed. 303 16

Williams Mfg. Co. v. United Shoe Mach. Corp., 316 U. S. 364, 63 S. Ct. 1179, 86 L. Ed. 1537 1

Wintermute v. Redington (C. C. Ohio, 1856), Fed. Case 17, 896, 1 Fish Pat. Cas. 239, 30 Fed. Cas. 367 18

Texts.

Deller, "Principles of Patent Law For The Chemical Metallurgical Industries," page 200 10

Walker, Deller's Edition, Volume 1, page 55 10

In the Supreme Court of the United States

OCTOBER TERM, A. D. 1947.

No. 280.

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

REPLY BRIEF FOR PETITIONER.

I. THERE ARE NO CONCURRENT FINDINGS OF THE COURTS BELOW.

The Respondent at the outset of its brief on page 4 and again on page 32 would lead this Court into believing that Petitioner's position has been twice rejected by the Courts below and thus gain to itself the benefit of the effect of concurring opinions under cases decided by this Court such as *Williams Mfg. Co. v. United Shoe Mach. Corp.*, 316 U. S. 364, 63 S. Ct. 1179, 86 L. Ed. 1537.

It is apparent there are no "concurrent" findings of the Courts below which would invoke the rule of the *Williams* case. The District Court was clear in its finding that the claims in suit "do not involve the *invention* or *discovery* of 'any *new* and *useful* art, machine, manufacture or composition of matter'." To declare there were "concurrent" findings on "(1) novelty," "(2) utility" and "(3) the quality of inventiveness" in the light of the findings of the District Court is not in accord with the facts. It is on the result of these findings and the application of the law to them that the Court of Appeals differed with the District Court.

II. PETITIONER HAS MADE NO CONFESSION OF NO ANTICIPATION.

Petitioner has made no confession that there is no anticipation by prior art. We state clearly in footnote 4, page 4 of our brief that Bond's ideas are old, but it is immaterial here as "there is no invention." Petitioner's position is set forth on page 15 of its brief, which we quote again:

> *"It makes no difference whether Bond discovered inhibition or not. It makes no difference if it was new. It is still a law of nature, used without modification or creation of an art, machine, manufacture or composition of matter. It is, therefore, not invention."*

III. MIXED INOCULANTS ARE OLD.

Mixed inoculants are old. Otherwise, Bond would not have been confronted with his alleged problem that sometimes the bacteria inhibit one another. The Bond patent states that mixed cultures were old. (Page 4, left column, lines 63 to 71, R. 776.) All that Bond claims to have discovered in his patent is the characteristic of non-inhibition in some strains of bacteria. But he does no more than use these kinds of bacteria in the mixed inoculant that was known prior to his patent.

The error of the Circuit Court of Appeals and of the Respondent is in the assumption that because of the discovery of this natural characteristic of non-inhibition, the inoculant that contained the bacteria having this characteristic was new; and because it was new, it was patentable. But Bond fails to point out any novelty in the product using the non-inhibitive bacteria that is different from anything occasioned by this bacteria when present in any other mixed inoculant, whether his or of the prior art.

Petitioner has already pointed out in its brief on page 30 that "articles of manufacture may be new in a commercial sense when they are not new in the sense of the patent law." *Collar Co. v. Van Dusen*, 23 Wall. (90 U. S.)

530, 563, 23 L. Ed. 128. A product may be new commercially but if it fails to comply with the prerequisite of either "newness" or "invention" as required by the statute (R. S. 4886) the product is not patentable. As we have already pointed out in our brief, page 31, this Court has said, in *Collar Co. v. Van Dusen, supra*:

> "Nothing short of invention or discovery will support a patent for a manufacture any more than for an art, machine, or composition of matter, for which proposition there is abundant authority in the decisions of this Court.†"

"† *Hotchkiss v. Greenwood*, 11 How. 265, *Phillips v. Page*, 24 How. 167; *Jones v. Morehead*, 1 Wall. 162; *Stimpson v. Woodman*, 10 Wall. 121."

See also:

Dunbar v. Meyers, 94 U. S. 187, 196, 197, 24 L. Ed. 34; *Roemer v. Simon*, 95 U. S. 214, 217, 218, 24 L. Ed. 384.

IV. BOND HAD NO NEW COMPOSITION OF MATTER AND ATTEMPTS TO INCORPORATE LIMITATIONS BY INFERENCE.

The Respondent claims that the Bond product is a new composition of matter, with a large number of bacteria.

The alleged newness of the product is founded on the holding of the Circuit Court, and to sustain its position of novelty the Respondent would lead this Court to believe that Mr. Bond overcame an "insurmountable" difficulty and solved "a problem of thirty years' standing" that had retarded the development of mixed inoculants when he discovered that in nature there existed both inhibitive and non-inhibitive strains of legume bacteria.

There is not a shred of evidence in the Record which proves that any mixed inoculant known prior to Bond failed because of the inhibitive effect of one species of bacteria on another. He alleges this, but there was no proof offered that this was the reason why any of the prior mixed inoculants had passed from the commercial

market. The fact is there was no real commercial demand by the farmers for such a product.[1]

The Respondent bases its position of alleged failure of mixed inoculants before the time of Bond largely on the report of Max Kronenberger[2] which was directly refuted by Petitioner's expert, Dr. Hofer, as stated in Petitioner's Brief, page 14.

The Respondent's effort to show that he has a new composition enlarges the claims of the patent to include in them by inference "large numbers of each species of bacteria." He attempts now to deny his own claims and limit them by inference with inclusion of elements that are not there, in an effort to show a "new composition."

At least on pages 13, 14, 15 and 57 of Respondent's Brief, he attempts to bring out this new factor for the purpose of reading it into his claims to make out a new composition of matter. Not a single claim of the patent makes any mention of "large numbers" of bacteria. "Numbers

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[1] R. 190, 191, 195, 196.

[2] The Respondent, on pages 10 and 11 of its brief, would lead this Court to believe that extensive scientific investigations had been made by those skilled in this art to determine the "causes of the failure of mixed cultures to provide the same degree of nitrogen fixation as single cultures prior to the Bond invention."

Such is not the fact, as admitted by Plaintiff's witness, Robert H. Burris, who stated that "Nobody was particularly interested in it." (R. 349.) At least, the scientific world was not interested in the alleged problem so readily put forward by the Respondent as that which presented itself to Bond at the time of his invention.

The Respondent could find no article by any scientist of real repute to support its position and was forced to rely upon one by Max Kronenberger of the Bavarian Cultural Institute for Plant Culture and Plant Protection, Munich, Germany (PX-11, R. 383, 394), as the basis for its statement of the problem that allegedly existed. This article is clearly refuted by the scientific investigations made by Petitioner's expert witnesses in the reports of their investigations (DX-5, R. 446; DX-7, R. 471; DX-13, R. 482 to 487; DX-29, R. 670, 671), which show that the normal expected condition, when the legume bacteria are mixed together, is that a beneficial result will be obtained by the mixture rather than a detrimental effect, as alleged by Bond. Significantly, Kronenberger alleges

(Continued on following page)

of substantially the same order of magnitude" or equal numbers are not "large numbers" which the Respondent now interprets into its claims in an effort to strengthen them. Where one seeks and obtains broad claims, he cannot later narrow them merely by inference and inclusion of factors that are not actually in the claims. This is contrary to the law as set forth in *Smith v. Hall*, 301 U. S. 216, 232, 57 S. Ct. 711, 81 L. Ed. 1049:

> "The Petitioner [the Respondent here] having sought and obtained a broad construction of his claim, cannot now narrow it so as to avoid anticipation by showing that the claimed method [product here] was used in a particular form of structure not claimed." (Editorial notes ours.)

V. BOND'S CLAIMS ARE NOT LIMITED TO CRITICAL FACTORS SET FORTH IN RESPONDENT'S BRIEF.

In addition to the large numbers of each species of bacteria which the Respondent now claims to be a critical element of the product, he alleges that it is also critical that the "large numbers" be "in a powder base of low

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(*Continued from preceding page*)

every mixed culture is detrimental; Petitioner's expert, Dr. Hofer, following the procedure of the Kronenberger article, found exactly the opposite effect, namely, a beneficial result. Dr. Hofer's test results were not challenged by Respondent and thus stand undisputed on the record.

Respondent's brief, on page 11, would infer that Petitioner's expert, Dr. Lewis Erdman, demonstrated the impracticability of mixed cultures. Dr. Erdman's statement quoted by Respondent could apply only when a plurality of different bacteria are actually *grown* together. This statement does not apply when bacteria are grown separately and then mixed together. Dr. Erdman clearly stated that he could very easily produce the Bond mixed culture merely by mixing bacteria together. (R. 145.)

> "We could grow a pure culture liquid suspension of a selected number of strains of alfalfa group bacteria in one tank. In another tank we could grow the red clover group of bacteria, and in a third tank our selected strains of soybean bacteria. We could mix these suspensions separately with the humus and then mix equal portions of the alfalfa, clover and soybean Nitragin. This would be the equivalent of Uni-Culture." (The Bond product.)

nutrient" "which eliminates the danger of one species of bacteria overgrowing the others." (Br. 15.) This claim of the use of a low nutrient value in the base to control growth of the bacteria is not an element of any of the claims except the faintest suggestion in claims 8 and 13. Any effort of the Respondent now to include by inference such a factor in the claims to show a new composition of matter is contrary to the law. *Smith v. Hall*, 301 U. S. 216, 57 S. Ct. 711, 81 L. Ed. 1049.

Further, there is absolutely no mention in any of the claims of the Bond patent that the bacteria must be arranged in numbers in the base so that they will not outgrow one another, which he now says is so important. (Br. 15.) The Respondent completely overlooks the fact that these factors were known in the art long before the Bond patent.[1]

VI. RESPONDENT ADMITS MIXED INOCULANTS ARE OLD.

Respondent admits that mixed inoculants were sold prior to the Bond patent (Br. 20), but it seeks to avoid the effect of these prior products by waving them aside as of "negligible importance" and that there is a "signal difference in kind" between mixed inoculants for "field seeds" and mixed inoculants for "garden seeds." (Br. 34.) However, there is not a single statement in the Record to prove the truth of these assertions. The fact is, there is no difference in the natural functioning of mixed inoculants for use on field or garden seeds.[2]

The trouble with the Respondent's position is that the claims of the patent, like claims 4 and 5[3] cover only a mixed inoculant in which there are strains of bacteria that have the non-inhibitive characteristics. This leaves the claims with the alleged discovery of the natural characteristics of

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[1] R. 161, 166, 169.

[2] R. 297.

[3] R. 779.

the bacteria as the only thread of possible distinction over anything that preceded Bond. But the discovery is not patentable. *LeRoy et al. v. Tatham, et al.*, 14 How. (55 U. S.) 156, 14 L. Ed. 367.

The difficulty with Respondent's position here, is that a mixed inoculant was no invention of Bond, neither are the natural characteristics of the bacteria an invention of Bond. These characteristics were present or absent in any mixed inoculant before Bond as the inhibitive or non-inhibitive kinds of bacteria were present or absent from the inoculant.

This leaves the Respondent in the position of endeavoring to read into the claims, which are product claims, a functional statement as a matter of definition at the exact point of novelty, which is contrary to law. *Halliburton Oil Well Cementing Co. v. Walker et al.*, 329 U. S. 1, 67 S. Ct. 691, 91 L. Ed. 15. The whole basis of the Respondent's position is to read into the claims what is *not* there in order to present some basis of alleging that the Bond product is a novel composition of matter—this, because Bond realizes that this is the critical point of the case, upon which he has failed to sustain the burden of proof.

VII. MERE DISCOVERY OF LAW OF NATURE IS NOT INVENTION.

Assuming that all that Respondent says is true, which we controvert, there is still no invention in the Bond product because a mere discovery of the natural, non-inhibitive characteristic of the bacteria and a selection of them is not invention. Neither a discovery nor a selection is patentable. *LeRoy et al. v. Tatham et al.*, 14 How. (55 U. S.) 156, 14 L. Ed. 367; *Hotchkiss v. Greenwood*, 11 How. (52 U. S.) 248, 13 L. Ed. 683; *Old Town Ribbon & Carbon Co. v. Columbia Ribbon & Carbon Mfg. Co.*, 159 F. (2d) 379.

To make an invention, the discoverer of a law of nature must apply the law in such a way as to produce a

man-made creation, that is, something that did not exist before. In this respect, we ask—what did Bond create that was not in existence before him? The answer is—nothing. Mixed inoculants were known before Bond; he uses the same bacteria that has always existed in nature; he uses the same base or carrier; all of the tests that he applies for efficiency were old and well-known before Bond. All of this he admits, as we have pointed out in our brief, pages 12 and 13.

Invention involves the use of the law of nature to create a novel structure, as this Court has held in *Mackay Radio & Telegraph Co v. Radio Corporation of America*, 306 U. S. 86, 94, 59 S. Ct. 427, 83 L. Ed. 506.

> "* * * a novel and useful structure created with the aid of knowledge of scientific truth may be [patentable]." (Editorial note ours.)

Every case is uniform in this requirement, that a man-made invention is necessary to apply the law of nature before a patent can legitimately issue.

Therefore, the statement of the Circuit Court of Appeals for the Seventh Circuit that "the discovery of a natural phenomenon, or of a quality or attribute of a well-known article and application of that quality in a successful combination which is of value to mankind is entitled to patent protection," is in error.

It takes more than a discovery and an application of the discovery into a successful combination to entitle one to patent protection. There must be the attribute of "invention" and there must be the attribute of "newness." The mere fact that a combination is successful upon the application of a discovery of a natural phenomenon to it is insufficient to entitle one to patent protection under the law, as this Court has stated in *Cuno Engineering Corporation v Automatic Devices Corporation*, 314 U. S. 84, 90, 62 S. Ct. 37, 86 L. Ed. 58.

"* * * Under the statute (35 U. S. C. § 31; R. S. § 4886) the device must not only be 'new and useful' it must also be an 'invention' or 'discovery.' *Thompson v. Boisselier*, 114 U. S. 1, 11. * * *"

The mere fact that Bond was the first to combine successfully in a "commercial product" bacteria so that they do not cooperate and do not affect one another, is not invention, because mere "novelty" or mere "utility" alone will not sustain invention. Bond admits this in Respondent's brief when he says that it is necessary to have in addition to novelty and utility, "the quality of inventiveness." (Br. 43.) Bond admits, therefore, that something must be created by the inventor. But, we ask here, what did Bond create? The answer is—nothing, for the mixed inoculant was known before Bond and the bacteria have been in existence since time immemorial.

VIII. BOND'S INOCULANT IS NOT A TRUE COMPOSITION OF MATTER.

A composition of matter must be more than a collection of bacteria which do not affect one another. A composition of matter, under the statute, pre-supposes an invention. The Bond inoculant is no more than a collection of natural bacterial life *per se*, into a common base. It fails of the test of invention for the reason that natural bacterial life *per se* had been collected together in a common base before Bond. His only contribution, if we deem it such for purpose of argument, is the finding that in the collection of bacterial life *per se* in previous mixed inoculants, some of the bacterial life was inhibitive and other was non-inhibitive. Bond merely took out of the prior mixed inoculants that kind of bacterial life that was inhibitive and left in that bacterial life that was non-inhibitive. Even Bond himself admits that the prior mixed inoculants could contain both inhibitive and non-inhibitive bacteria. (See footnote 18, page 9, Petitioner's Brief.)

"A patent monopoly is not to be extended to the use of a class of materials, some of the members of which are shown not to be effective in carrying out the inventive process." *Libby-Owens-Ford Glass Co. v. Celanese Corporation*, 135 F. (2d) 138, 145. So here, where the Bond patent claims are not limited to the use "only" of non-inhibited strains of bacteria,[1] the patent monopoly should not be given to Bond.

Also, where there is only a mere association of non-cooperating elements, there is no invention. In the case of *Metals Recovery Co. v. Anaconda Copper Mining Co.*, 31 F. (2d) 100, the question before the Court was concerning a material in which there were both "frothing" oils and "collecting" oils, neither of which had any particular co-operation with the other. The specific question was whether it was invention to bring together "two substances each of which performs but one of the two requisite functions." The Court said that "such a conception we hold was familiar to the art."

So here is the conception of association of two bacteria either of which performs but one of the two requisite functions desired of the mixed inoculant; there is no "new" composition of matter, for the bacteria had previously been associated in prior mixed inoculants. As stated by *Walker*, Deller's Edition, Volume 1, page 55, "To be a proper subject of a patent, a composition of matter must, like a process, a machine, or a manufacture, meet all the requirements of invention, novelty, and utility." This the Bond product fails to do.

In "Principles of Patent Law For The Chemical Metallurgical Industries" by Anthony William Deller, page 200, he classifies a composition of matter as follows, quoting from Robinson in his classical work on patents:

"A composition of matter is an instrument formed by the intermixture of ingredients possessing proper-

---

[1] See Claim 5 of Bond patent. (R. 779.)

ties which belong to none of these ingredients in their separate state.''

This is in further support of the Petitioner's position, pages 27 and 28 of its brief. In the case of *Pickering v. McCullough,* 104 U. S. 310, 317-318, 26 L. Ed. 749, the Court said:

> ''We are clearly of opinion that this is not patentable. It comes plainly within the rule, as stated by Mr. Justice Strong, in *Hailes v. Van Wormer* (20 Wall. 353, 368), where he said: 'All the devices of which the alleged combination is made are confessedly old. No claim is made for any one of them singly, as an independent invention. It must be conceded that a new combination, if it produces new and useful results, is patentable, though all the constituents of the combination were well known and in common use before the combination was made. But the results must be a product of the combination, and not a mere aggregate of several results, each the complete product of one of the combined elements. Combined results are not necessarily a novel result, nor are they an old result obtained in a new and improved manner. Merely bringing old devices into juxtaposition, and there allowing each to work out its own effect, without the production of something novel, is not invention.' ''

IX. PETITIONER NEED NOT RELY ON INVALIDITY BY REASON OF ANTICIPATION FOR BOND HAS NO INVENTION.

Petitioner does not rely upon invalidity by reason of anticipation because you must have an invention under the law before you need the defense of anticipation. This does not mean that we think that whatever Bond did is not old, because it is, and his own admissions in his testimony indicate that to be a fact. Respondent's patent does not meet the test of invention.

Therefore, Petitioner does not need to raise the issue here, that is, of invalidity by reason of anticipation, be-

cause it makes no difference whether the thing is new or old. We conclude, therefore, that whether Bond had a new or old idea, or whether Bond was the first to discover non-inhibition, or whether Bond was the first to use non-inhibitive bacteria, or was the first to use a low nutrient, or was the first to use large numbers of bacteria—all these things make no difference: there is still no invention, for everything rests upon the one factor of the discovery of the natural characteristics of bacteria, which characteristics have been in existence in the bacteria from time immemorial.

Even assuming everything that Bond claims in Respondent's brief is true, he has still created no "new" composition of matter, which is the foundation upon which any invention must be predicated.

On this issue, the District Court disagreed with Bond and found that he had not made any "invention" or "discovery" of any "new" and "useful" art, machine, manufacture, or composition of matter.

The Circuit Court of Appeals for the Seventh Circuit did not disagree in effect, with the District Court as to the facts of the case, but only with the result as determined by the application of the law to the facts. The Circuit Court of Appeals merely held that Bond had a composition of matter and because he had a composition of matter, it was an invention.

X. NOVELTY AND UTILITY ARE INSUFFICIENT TO SUPPORT INVENTION.

Let us now take Respondent's position that Bond discovered the existence of non-inhibitive bacteria, and assume he is correct in his claim of novelty and utility, all of which is denied—yet he still does not have invention for the following reasons:

A. Novelty and utility alone are insufficient to constitute patentability. Respondent says this in his brief

(Br. 43). Thus, all argument urged by the Respondent as to novelty and utility falls by the wayside, unless the quality of inventiveness is also present.

B. Bond does not have "the quality of inventiveness" in a "new" composition of matter because in applying the law of nature to his product he has done nothing to change the old combination of a mixed culture, except to use non-inhibitive bacteria. Respondent does not pretend that Bond invented either mixed inoculants or the bacteria. He does not have a "new" composition because "the composition" of a mixed inoculant was old before Bond. Since he did not invent the bacteria, he can have no invention.

Therefore, his discovery of non-inhibitive bacteria has not been used by him to produce a "novel and useful structure created with the aid of knowledge of scientific truth" as required in *Mackay Radio & Telegraph Co. v. Radio Corporation of America*, 306 U. S. 86, 94, 59 S. Ct. 427, 83 L. Ed. 506. As stated in *LeRoy, et al. v. Tatham, et al.*, 14 How. (55 U. S.) 156, 14 L. Ed. 367; an invention arises under the law of nature only if the principle is applied to a special purpose "to effectuate a practical result and benefit not previously attained"; and further "invention is not in discovering them [laws of nature] but in applying them to useful objects." Useful objects under the law must be an "invention" or a "discovery" and must be "new" and "useful" as held by this Court in *Cuno Engineering Corporation v. Automatic Devices Corp.*, 314 U. S. 84, 90, 62 S. Ct. 37, 86 L. Ed. 58.

The Respondent's statement of the invention of the Bond patent on pages 12 and 13 of its brief does not meet the required test. It will be noted that this statement departs from the claims of the patent in that the Respondent includes in the statement of invention factors that are not a part of the claims of the patent. These factors are that

the product shall contain (1) "a base material substantially free of nutrients" and (2) "large numbers of each species of bacteria." The latter of these factors is nowhere contained in any of the claims and the low nutrient value of the base is only hinted at in claims 8 and 13. *Hence, if these factors are essential to Respondent's position of novelty, newness and invention, the claims fail of patentability.*

C. The Respondent injects into these product claims statements of function at the exact point of novelty, which statements of function concern only the process by which the product is obtained. The statement of function as to the inhibition of the bacteria with respect to one another is not descriptive of the product but is descriptive only of the bacteria. Hence, it is no limitation of the product *per se*, and without this limitation the product *per se* becomes the product of the prior art. Thus, the functional language of the claims falls within the condemnation of this Court in *Halliburton Oil Well Cementing Co. v. Walker, et al.*, 329 U. S. 1, 67 S. Ct. 6, 91 L. Ed. 15.

XI. DISCOVERY OF A NEW USE OF A LAW OF NATURE, WITHOUT MORE, IS NOT INVENTION.

A discovery of a new use for a law of nature, without more, is not patentable invention. The "discovery," as a discovery of natural functions, might be new but the result performed by the natural functions of the elements, in this case the bacteria, is not new. Hence, a discovery of a new law of nature and its application to a corporal element can rise to the dignity of invention only if the statutory requisites of novelty, utility and inventiveness are met with some "new" mechanical combination or method to utilize that discovery or that law of nature in a way that it had not been used before.

As the Respondent has stated, "Man is incapable of changing or modifying the immutable laws of nature," but

merely using these immutable laws of nature without more, does not rise to the dignity of invention. The discoverer must at least control the laws of nature so that he can make it do his bidding, to produce a new and useful result. *Telephone Cases*, 126 U. S. 1, 8 S. Ct. 778, 31 L. Ed. 863. But here, Bond does not control the law of nature that he has discovered. He uses it in exactly the same way that it has always performed in nature without any control, and hopes that he will obtain the result that he desires.

XII. COMMERCIAL SUCCESS ALONE DOES NOT SUPPORT INVENTION.

Invention does not lie in any device or product merely for the reason that it is a tremendous commercial success. While commercial success may tip the scales in favor of an invention when patentability is in doubt, yet commercial success alone, regardless of how great, will never take the place of the statutory requisites of invention. *Dow Chemical Co. v. Halliburton Oil Well Cementing Co.*, (C. C. A. 6, 1943), 139 F. (2d) 473, affirmed (1945) 324 U. S. 320, 330, 65 S. Ct. 647, 89 L. Ed. 973; *Kissock v. Duquesne Steel Foundry Co. et al.* (C. C. A. 3, 1929), 37 F. (2d) 249, 251, c. d. 281 U. S. 749, 50 S. Ct. 354, 74 L. Ed. 1161; *Univis Corporation et al. v. Rips et al.* (C. C. A. 6, 1939), 104 F. (2d) 749, c. d. 308 U. S. 592, 60 S. Ct. 121, 84 L. Ed. 495; *Gerald M. Friend, Inc. v. Walsh et al.* (C. C. A. 2, 1944), 141 F. (2d) 180, 182.

Hence, all that Respondent says concerning commercial success, commercial practicability and commercial use of the Bond invention is of no avail unless the statutory requisites of invention are present in the product itself, which we have shown herein are not.

XIII. FUNCTIONAL LANGUAGE IN THE CLAIMS IS IMPROPER WHEN OTHER LANGUAGE IS AVAILABLE.

The Respondent would complain that the patent claims are defined in the only language available to the art. (Br. 63 to 71.) However, the Respondent was able in its brief to point out factors that should be interpreted into the claims for purposes of limitation to give the Bond invention novelty, utility and inventiveness. We do not find that these limitations are in the claims. It is clear, therefore, that the Respondent could have more clearly and more accurately described the product as he did in his brief. However, the Respondent preferred not to limit his claims to the factors that he now says are so essential to novelty and utility, and insisted upon and obtained the broad claims of the patent.

It is therefore clear that the physiological characteristics of the bacteria are not the only terms available to the patentee in describing what he now claims as his invention. Since there are other ways, as he has shown in his brief, by which the invention could have been claimed, he cannot now be heard to complain because the functional language that he used at the exact point of novelty in the claims falls within the condemnation of the decisions of this Court. *Halliburton Oil Well Cementing Co. v. Walker et al.*, 329 U. S. 1, 67 S. Ct. 6, 91 L. Ed. 15 to which we have called attention in our brief, pages 38 and 39. The mere fact that the patentee could not at that time find language suitable to describe what he now claims as his invention, when he has shown in this brief that such language was available, is no excuse for his failing to define definitely and conclusively what are his invention and claims. *General Electric Co. v. Wabash Appliance Corp. et al.*, 304 U. S. 364, 372, 373, 58 S. Ct. 899, 82 L. Ed. 1402; *White v. Dunbar*, 119 U. S. 47, 51-52, 7 S. Ct. 72, 30 L. Ed. 303; *In re Ewald* (C. C. P. A., 1941), 117 F. (2d) 755, 757; *In re Hegan* (C. C. P. A., 1938), 97 F. (2d) 86, 88.

XIV. RESPONDENT'S STATEMENT OF PETITIONER'S POSITION IS INCORRECT.

The statement on page 31 of Respondent's Brief is in error as to Petitioner's position. Our position has been stated in Petitioner's Brief, page 15, and restated in this reply, page 2. While it is true, that we have previously urged the point that the theory of the Bond patent is false, and that inhibitive strains do not exist generally, we have assumed for the purpose of argument in this Court that Bond is correct in his finding of inhibition and non-inhibition among the *strains of bacteria.*

Likewise, without conceding that there is no anticipation by prior art, as stated in footnote 4, Petitioner's Brief, page 4, we have, for the purpose of argument, waived the question as to whether or not the function is there. With the position the Petitioner has taken for purposes of argument before this Court, it makes no difference what the theory is concerning the Bond patent or what mixed inoculants did or did not do, for Bond merely discovered a law of nature and without more, used it and thus does not have an "invention."

XV. SPECIFIC ANSWERS TO RESPONDENT'S BRIEF.

1.

On page 36 of Respondent's Brief he states that the principle was established by *LeRoy et al. v. Tatham et al.*, 14 How. (55 U. S.) 156, 14 L. Ed. 367, to the effect "that application of a principle or law of nature in a useful article of commerce is patentable," but that is not true. *LeRoy v. Tatham*, after announcing the rule that "a principle * * * cannot be patented * * *" went on to say that "a patent will be good * * * if that principle is by the specification applied to any special purpose, so as thereby to effectuate a practical result and benefit not previously attained." This was not said without due regard to the statute which requires that an invention be an "invention" or a "discovery" and be "new" and "useful," for in this

case a new wrought pipe had been made as distinguished from a cast pipe. Thus, the case of *LeRoy et al. v. Tatham et al.* did not overlook the newness required by the statute, as the Respondent would indicate by his statements.

2.

On pages 37, 38, 39 and 40 the Respondent refers to the decisions of this Court, and other Courts, and from them draws the inference that a patent will be good if a new property is discovered in matter and this is practically applied to obtain a beneficial result, it being the application of the law of natural science or rule which constitutes the peculiar feature of the invention.

Without more, this is not true, for it would avoid the statute which requires "invention," "discovery" and that the device created be "new" and "useful."

All of the cases referred to by the Respondent come back to the one proposition, that you must have a "new" and "useful" structure before you can have a patentable invention.

In *LeRoy et al. v. Tatham et al.*, 14 How. (55 U. S.) 156, 14 L. Ed. 367, there was a "new" kind of pipe created, it being "wrought" instead of "cast." In *Wintermute v. Redington* (C. C. Ohio, 1856), Fed. Case 17,896, 1 Fish Pat. Cas. 239, 30 Fed. Cas. 367, the claim was to a new mechanical arrangement of elements which utilized natural principles. However, the apparatus was "new." In *Sewall v. Jones*, 91 U. S. 171, 23 L. Ed. 275, the patent claim was to a method of preserving corn which included removing the kernels from the cob, placing the kernels in cans, sealing them, and exposing them to heat. Natural principles were involved, but the patent was on the specific process. However, the patent was declared invalid for want of novelty. In *Cameron Septic Tank Co. v. Village of Saratoga Springs* (C. C. A. 2), 159 Fed. 453, c. d. 209 U. S. 548, 28 S. Ct. 759, 52 L. Ed. 921, the patent covered the process steps which had not

previously been used in the particular form and order and the process therefore was "new."

This is all summed up in this Court's decision in *Mackay Radio & Telegraph Co. v. Radio Corporation of America,* 306 U. S. 86, 94, 59 S. Ct. 427, 83 L. Ed. 506 wherein it is stated: "* * * a novel and useful structure created with the aid of knowledge of scientific truth may be [patentable]." *The quality of newness is therefore essential in the decisions and in the statute, and this the Bond product does not have.*

The difference here is that the law of nature is God's property to be used by all people. The creation of something new in a physical sense when applying that law is man's creation. That is the subject of invention. The difficulty with the Respondent's position is that the Bond product does not meet the test of being a "new" physical substance.

3.

On page 48 of its brief Respondent alleges that the Petitioner takes the position that Bond must make some change in the law of nature before he has a patentable invention. The fallacy of the Respondent's position is that the Respondent and the Petitioner know that laws of nature are unchangeable. The truth is, the Petitioner's position is that Bond must do more than merely use laws of nature without more, before he has an invention, and he must effect some result that is new even though he uses the laws of nature. All the cases so hold. It is the new physical structure that is patentable—not the law of nature.

4.

On page 54 of Respondent's Brief, he says that all that was claimed by Coolidge in the case of *General Electric Co. v. DeForest Radio* (C. C. A. 3), 28 F. (2d) 641, c. d. 278 U. S. 656, 49 S. Ct. 180, 73 L. Ed. 565, is pure tungsten, that is, a

product of nature *per se*. This is true as far as it goes, but the Respondent does not go far enough for the Coolidge patent also contained Claim 24 which reads as follows:

"24. A wire formed of ductile tungsten."

This claim was held invalid by the Court and the language of the Court in that case, from the second column, page 643 through the first column on page 644, is on all fours with the issue here if the Court will substitute "mixed inoculant" for the use of the word "wire" in the case, and "bacteria" for "tungsten."

What does Bond have? He has a mixed inoculant formed of non-inhibitive bacteria. Thus, Bond claims a product of nature in exactly the same way that Coolidge was claiming his product of nature and seeks to pass off his claim as being a "corporal embodiment capable of practical use and which does not exist in nature." So was Coolidge's wire "a corporal embodiment capable of practical use which did not exist in nature" but this did not save his claim from being invalid. *So, here, this should not save Bond's claim from being invalid.*

5.

On page 56, the Respondent states what he considers to be the Bond invention. He says that it is (a) a combination of selected bacterial strains (b) placed together in a specified condition, i.e., (c) in large numbers, (d) in a powder base of low nutrient.

But let us look at the claims. No one of them makes any mention of "large numbers" of bacteria and only Claims 8 and 13 make even a casual mention of a base "of low nutrient," and even here this is in indefinite terms of "substantially negligible concentration of bacterial nutrients."

The Respondent has tried to show a composition of matter by now including in the claims factors that are not

actually in them. The broad terminology of the claims cannot now be saved by interpreting into them limitations that are not actually there. This is contrary to law. *Smith v. Hall*, 301 U. S. 216, 57 S. Ct. 711, 81 L. Ed. 1049.

XVI. PUBLIC IMPORTANCE.

The Respondent on page 71 of its brief would pass over the public importance of this case. But let us look for a moment at the result that can and will occur if this patent on elements of nature is sustained.

If this patent is sustained, no one can even follow the prior art practices of making mixed inoculants in exact accordance with the prior art methods.

That mixed inoculants are old is admitted by Respondent. The record is clear that prior to Bond, bacteria of different kinds have been mixed together in a common base. Before Bond no one cared whether inhibited or non-inhibited kinds of bacteria were placed in the mixed inoculant. Since both existed, both found their way into the mixed inoculants of the prior art, and this is admitted by Bond himself.

Now with the advent of the Bond patent, Bond says that he discovered non-inhibited bacteria and that he has a monopoly on any and every mixed inoculant in which there is "at least one" strain of non-inhibited bacteria.[1]

Needless to say, if the prior art practices of merely indiscriminately mixing bacteria together in a common base is followed, inhibited and non-inhibited bacteria will find their way into the inoculant. But now with the advent of the Bond patent, this, according to Bond, is barred. Thus, Bond is not only endeavoring to protect an alleged invention, but he is endeavoring to stop the practice of prior art methods.

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[1] See Claim 5, R. 779.

As this Court stated in *Foley, Admx. of Gathmann v. United States*, 260 U. S. 667, 676-677, 43 S. Ct. 240, 67 L. Ed. 451:

> "If the asserted result was inevitable in the method of the patents, it was inevitable in the method in use prior to the patents."

Respectfully submitted,

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IN THE

SUPREME COURT OF THE UNITED STATES

OCTOBER TERM, 1947

No. 280

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

BRIEF OF RESPONDENT IN OPPOSITION TO PETITION FOR WRIT OF CERTIORARI.

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Counsel for Respondent.

THE TWENTIETH CENTURY PRESS, INC., CHICAGO

INDEX.

PAGE

ESTATEMENT OF THE FACTS 3

RGUMENT 10

THE COURT BELOW DID NOT UPHOLD THE BOND PATENT IN SUIT FOR MERELY DISCLOSING AND CLAIMING THE DISCOVERY OF A LAW OF NATURE 10

1. The Opinion of the Court Below Is Not in Conflict with the Principles of Decisions of This Court 10

2. The Opinion of the Court Below Is Not in Conflict with Decisions of Other Circuit Courts of Appeals 14

3. The Inoculant Disclosed in the Bond Patent in Suit Is Properly Classifiable as a Composition of Matter. The Claims in Suit Are Not Invalid Merely Because Bond's Inoculant Makes Useful Application of a Law of Nature 18

. THE SEED INOCULANT INDUSTRY IS NOT CONCENTRATED IN OR SUBJECT TO THE SEVENTH CIRCUIT. NO QUESTIONS OF IMPORTANCE TO THE PUBLIC AS DISTINGUISHED FROM THE PARTIES ARE INVOLVED IN THIS CASE 21

I. THE BOND CLAIMS DEFINE THE NEW PRODUCT DISTINCTLY AND EXACTLY. THEY FULLY MEET THE REQUIREMENTS OF THE STATUTE (R. S. 4888) 24

ONCLUSION 26

PPENDIX (AFFIDAVIT OF MYRON E. LUSK) 28

PAGE

TABLE OF CASES.

American Fruit Growers, Inc. v. Brogdex, 283 U. S. 1. 20, 21

J. E. Baker Co. v. Kennedy Refractories Co. (C. C. A. 3), 253 Fed. 739. 20

Bodkin v. Edwards, 255 U. S. 221, 223. 27

Burr v. Duryee, 1 Wall. 531, 570. 13

Corona Co. v. Dovan Corp., 276 U. S. 358. 14

Cuno Engineering Corp. v. Automatic Devices, 314 U. S. 84. 20

DeForest Radio Co. v. General Electric Co., 283 U. S. 664. 14

Dennis, et al. v. Pitner, et al., 106 F. (2d) 142. 15, 16

Exhibit Supply Co. v. Ace Patents Corp., 315 U. S. 126. 22

Furness, Withy & Co., Ltd. v. Yang-Tsze Ins. Ass'n Ltd., 242 U. S. 430, 433. 2

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Halliburton Oil Well Cementing Co. v. Walker, 329 U. S. 1. 24

Hotchkiss v. Greenwood, 11 How. 248. 20

Household Co. v. Nielsen, Websters Pat. Cases, 683. 12

Katz v. Horni-Signal Mfg. Corporation (C. C. A. 2), 145 F. (2d) 961. 18

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Layne & Bowler Corp. v. Western Well Works, 261 U. S. 387, 393. 2

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Mackay Radio & Tel. Co. v. Radio Corp. of America, 306 U. S. 86, 94. 11, 19, 21

PAGE

Missouri-Kansas-Texas R. R. Co. v. Texas, 275 U. S. 494 10

Morton v. New York Eye Infirmary, 17 Fed. Cas. 879, 881 ..... 16, 17

Muncie Gear Works, Inc. v. Outboard Marine & Mfg. Co., 315 U. S. 759 22

Novocol Chemical Mfg. Co., Inc. v. Powers & Anderson Dental Co., Inc., 128 F. (2d) 904, 907 17

O'Reilly v. Morse, 56 U. S. 62 13

Rubber-Tip Pencil Co. v. Howard, 20 Wall. 498 13

Schriber-Schroth Co. v. Cleveland Trust Co., 305 U. S. 47, 50 ..... 3, 22

Smith v. Nichols, 21 Wall. 112, 119 13

Southern Power Co. v. North Carolina Public Service Co., 263 U. S. 508 10

Telephone Cases, 126 U. S. 1, 534 ..... 12, 13, 21

Union Carbide Co. v. American Carbide Co. (C. C. A. 2), 181 Fed. 104, 106-7 20

United States v. McFarland, 275 U. S. 485 10

Vitamin Technologists, Inc. v. Wisconsin Alumni Research Foundation (C. C. A. 9), 146 F. (2d) 941 ..... 15, 16

Walker on Patents, Deller's Ed., Sec. 14, p. 55 20

Wall v. Leck, 66 Fed. 552 15

Williams Mfg. v. United Shoe Mach. Co., 316 U. S. 364 23

IN THE

SUPREME COURT OF THE UNITED STATES

OCTOBER TERM, 1947

No. 280

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

BRIEF OF RESPONDENT IN OPPOSITION TO PETITION FOR WRIT OF CERTIORARI.

May It Please the Court:

The issue presented by the petition is one predicated upon an assumption taken by petitioner contrary to the record and constitutes a misinterpretation and distortion of the opinion of the Court below.

The erroneous assumption of the false issue presented is that the Court below has upheld a patent monopoly "on a discovery of a law of nature and how it works, the patentee adding nothing to the operation of the law of nature either in mechanism or method." (Petition, p. 2.) On the contrary, the opinion of the Court below expressly found that the patentee (R. 824):

> ". . . did much more than discover a law of nature. He made a new and different compo[illegible]ion, one contributing utility and economy to the manufacture and distribution of commercial inoculants."

In essence, the petition really presents for review by this Court no more than a question of fact, *i.e.*, alleged lack of invention in an ordinary patent case, this question having been resolved in favor of respondent by the Court below on the basis of certain findings of fact made by the trial court and after a thorough re-examination of the evidence.

Petitioner does not challenge the concurrent findings of infringement made by the Courts below and significantly did not file a petition for rehearing.

While the facts of this case are clearly and accurately stated in the opinion of the Court of Appeals (R. 817-833, 161 F. (2d) 981), a short restatement of the matter involved is necessary because petitioner's statement wholly fails to disclose the real situation involved; it omits or minimizes essential facts, and is in sore need of correcting and supplementing.*

From our restatement and our comments on the petition's reasons for allowance of the writ, it will appear convincingly, we submit, that this is an ordinary patent infringement case involving the usual issues of validity and infringement; that no novel principle of patent law is present; that the opinion of the Court below is in harmony with the decisions of this Court; that there is no conflict between Circuit Courts of Appeals regarding the validity or scope of respondent's patent or regarding the applicable rules of decision; and that there are here no questions of importance to the public, as distinguished from the parties. In these circumstances, this Court has said that it will not grant writs of certiorari. *Keller* v. *Adams-Campbell Co.*, 264 U. S. 314, 319; *Layne & Bowler Corp.* v. *Western Well Works*, 261 U. S. 387, 393.

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* From *Furness, Withy & Co., Ltd.* v. *Yang-Tsze Ins. Ass'n. Ltd.*, 242 U. S. 430, 433, it appears that a respondent's duty to bring the real situation to the attention of this Court is no less than that of a petitioner.

Petitioner's effort to take advantage of the precedent established by *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 305 U. S. 47, 50, must fail also because it appears from petitioner's own statement that there are seed inoculant manufacturers located beyond the Seventh Circuit (Petition, p. 31). Thus, admittedly, it cannot be said that there is no probability of litigation in other circuits or of conflict among the circuits as to respondent's patent, and, therefore, the rationale of the *Schriber-Schroth* case is inapposite. In any event, the inaccuracy and grossly misleading character of petitioner's unverified assertions regarding an alleged concentration of the industry in or subject to the Seventh Circuit are revealed by the affidavit of Myron E. Lusk, presented herewith as an appendix to this brief (*post*, p. 28).

RESTATEMENT OF THE FACTS.

Prior to the Bond invention it was the general practice in the inoculant industry to manufacture and sell for use by the farmer only so-called single cultures or single inoculants (R. 142 and 147). Each inoculant contained only one species of root nodule bacteria, and accordingly could be employed successfully only on the plants of the particular cross-inoculation group corresponding to this species. Thus, in order to supply inoculants to an agricultural area wherein the principal crops include clover, alfalfa, and soy beans, for example, it was necessary for the dealer to maintain a stock of clover inoculant, a separate stock of alfalfa inoculant, and a separate stock of soy bean inoculant. In addition to requiring larger inventories, this practice of supplying single inoculants resulted either in an inadequate supply of inoculants for the farmer toward the end of the planting season or in loss to the dealer and the manufacturer if substantial stocks of the inoculant were left over at the end of the planting season (R. 140-141).

A mixed or composite inoculant, as distinguished from a single inoculant, contains root nodule bacteria of two or more species and may be used by the farmer to inoculate leguminous crops of more than one cross-inoculation group. To a layman it would seem, as it did to the early workers in the inoculant art, that the provision of a mixed culture would offer no problems over and above those involved in the provision of a single culture. Certainly the mere step of including one or more additional species of root nodule bacteria in the usual single culture would appear to offer no technical problems. Experience, however, prior to the Bond patent, was directly to the contrary.

As early as 1907 the advantages of mixed cultures were recognized and explained (see Earp-Thomas patent No. 865,965, R. 784, ll. 6-18, R. 785, ll. 57-76). During the ensuing decade various mixed inoculants were advertised for sale accompanied by glowing promises and extravagant claims as to beneficial results, but these products without exception were failures and disappeared from the market. The record establishes (R. 142) that there were no mixed cultures for field legumes on the market at the time the product of the Bond patent was first introduced to the trade. Prior to the Bond invention mixed inoculants had fallen into disrepute. They were considered impractical and were not offered for sale in competition with single cultures.*

The "Bible" of the inoculant industry (R. 125), published in 1932, and entitled "Root Nodule Bacteria and

* Mr. Bond testified (R. 137):

"The results obtained with these cultures were very uncertain. Sometimes they didn't even form nodules on the plants for which they were recommended. In other words, the need for a mixed culture was shown in the early history of these mixed cultures but none of them survived on the market, to my knowledge anyway, much after 1930 when there were more intensive culture tests made by the State and the United States Government institutions."

Leguminous Plants," by Edwin Broun Fred, Ira Lawrence Baldwin and Elizabeth McCoy, University of Wisconsin Studies, states at page 244 (R. 398) that "composite cultures offer few* advantages and certainly many disadvantages," and at page 254 (R. 401) that "it is desirable to have only the one type of organism in the culture."

The scientific investigations into the efficiency of mixed cultures and the causes of the failure of mixed cultures to provide the same degree of nitrogen fixation as single cultures prior to the Bond invention all pointed in the same direction, *i.e.*, toward the impracticability or even impossibility of producing a mixed culture which would have the same ability to promote nitrogen fixation when applied to leguminous plants as would a plurality of single cultures containing the same strains of bacteria. The deficiency of mixed cultures was ascribed to an inhibitive effect exerted by the different species of bacteria on each other which reduced the efficiency of the bacteria. In other words, although the different species of bacteria were found to be capable of living together, they would for some reason not function as well in association with each other as when used alone.

The most extensive investigation of this inhibitive effect made prior to the Bond invention is found in a report by Max Kronberger of the Bavarian Agricultural Institute for Plant Culture and Plant Protection, Munich, Germany (PX 11, R. 383-394).**

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* Emphasis ours throughout unless otherwise noted.

** Kronberger concluded (R. 393) that the mutual inhibition between different species of root nodule bacteria in so far as the nitrogen-fixing ability is concerned, was probably due to the differences in the metabolic products released by the different species, and he stated his ultimate conclusion to be (R. 394):

> ". . . And not the least important fact that can be seen from these experiments is that it would be a great mistake to use a universal inoculation material for the various types of legumes. **This would never give the same increase in yield as the employment of the particular culture indigenous to the plant.**"

The apparently insurmountable inhibitive effect encountered in mixed cultures was not the only difficulty involved in the preparation of a satisfactory product. It had long been known that the different species of root nodule bacteria were characterized by different rates of growth, some being very fast growers and some being very slow. Accordingly, placing two or more species of root nodule bacteria in a nutrient rich base, as had been suggested and taught in the prior patents and literature, would result in the faster growing species overgrowing the slower ones to the extent that by the time the product was to be used, there would be either a deficiency or a complete absence of the slower growing species of bacteria in the purported mixed culture. Dr. Erdman, one of petitioner's experts, commented on this problem in a report dated June 10, 1938, in which he criticized and undertook to demonstrate the impracticability of mixed cultures prepared in accordance with the teachings of the Bond patent.*

The problem faced by Mr. Bond was two-fold: first, the elimination or correcting of the mutually inhibitive effect, and second, insuring that the final product would contain the proper number of live and active bacteria of each species throughout the intended useful life of the product. The solution of this apparently insoluble problem by Mr. Bond stems from his extensive experiments which resulted in the unheralded discovery that there exist in nature certain strains of each species of root nodule bacteria which do not exert a mutually inhibitive effect on each other. Bond thereupon conceived that such mutually non-inhibitive

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* Erdman said (R. 145):

> "Another factor, which might seriously interfere with the efficiency of such a culture is the rate of growth of the different legume bacteria. . . . **It would be almost suicidal** to mix a slow growing organism like the soybean bacteria with fast growers like the alfalfa and red clover bacteria. Such a culture if prepared, say in January, would theoretically contain relatively few soybean bacteria when it would be used on soybeans in May or June."

strains could by proper methods of selection and testing be isolated for use in mixed cultures, and a final product containing throughout its expected life a sufficient number of live and active bacteria of each species, could be achieved by employing a base material substantially free of nutrients and by initially adding to this base material large numbers of the non-inhibitive strains of each species of bacteria, the number of each species being of substantially the same order of magnitude (R. 103).

Of this solution the Court below said (R. 824):

". . . This was application of scientific knowledge to things existing in nature and the utilization of them in a desirable composite product which had not been previously achieved but which he did achieve and of which the public now has the benefit.

"We think this is clearly within the decisive definitions of patentable invention. . . ."

Further the Court said (R. 827):

". . . So here Bond did a novel thing in the science of culture of bacteria to inoculate leguminous plants. He knew what other scientists already had suggested that certain strains worked adversely and detrimentally to each other. Delving further, he learned for the first time that various strains of the genus are non-inhibitive of other strains and can be grouped, with an entirely healthy result. As a result of his teachings, scientists learned how to make a composite inoculant without disastrous conflict of one species of bacteria with another. True, the composite inoculant had been thought of and practiced to some extent, but just as truly it had not achieved approved recognition. Indeed, scientists thought that it was a dangerous practice, and Bond, for the first time, pointed out to the bacteriologist the fact of existing non-inhibitive strains and instructed him that he should select such strains and make his composite inoculant of them. Thus he taught how to make a composite inoculant, successful, efficient and filling the need it was meant to fill. . . . It is inventive conception."

The claims in suit define a new product, *i.e.*, a mixed inoculant which is as efficient as single inoculants employing the same strains of bacteria. The patent does not purport to cover a "discovery of a law of nature," but rather a new product which prior to the discovery of a scientific truth and the application of scientific knowledge did not exist and could not have existed.

Petitioner at the trial and before the Court of Appeals based its "law of nature" defense on the assertion that Bond's theory of inhibition was false. Petitioner's experts testified that inhibitive strains do not exist. On this testimony petitioner urged that Bond therefore discovered nothing new, and that the product of the Bond patent was old in nature. This fact issue was determined against petitioner by the trial court, who commented on the "very great diligence and ingenuity" exercised by Bond (R. 744). The Court of Appeals reviewed the evidence on this fact issue, and, referring to the specific finding made by the District Judge, said (R. 820):

> ". . . However, he made a specific finding that Bond did discover that there exist in nature noninhibitive strains and that these noninhibitive strains may be selected, isolated and combined and still perform satisfactorily their ordinary desirable functions. Upon this finding there was controverted evidence, but our examination of the record is convincing that that supporting the finding is rather conclusive and that there is no justification for us to declare the District Court in error in making it."

Thus the concurrent findings of the courts below establish the diligence and ingenuity exercised by Bond, the merit of the results achieved, and the novelty and utility of the patented product. It is of this fact issue that petitioner indirectly seeks a review by its false statement of the issue and by its continued assertion that Bond "added nothing to the operation of the law of nature."

In answer to identical assertions by petitioner, the Court below said (R. 824):

> "... The noninhibitive property of bacteria was not previously known and when Bond discovered it and taught a successful composition of noninhibitive strains in combination of elements in one inoculant operating successfully on several different groups of legumes, **he did much more than discover a law of nature.** He made a new and different composition, one contributing utility and economy to the manufacture and distribution of commercial inoculants."

ARGUMENT.

I.

THE COURT BELOW DID NOT UPHOLD THE BOND PATENT IN SUIT FOR MERELY DISCLOSING AND CLAIMING THE DISCOVERY OF A LAW OF NATURE.

From the foregoing restatement of the facts, it is quite evident that the principal issues raised by petitioner concerning the abstraction "law of nature," and said to arise in this case, are not warranted by the real situation. As this Court consistently refuses to decide questions for which there is no substantial basis in the particular facts of a case (*Southern Power Co.* v. *North Carolina Public Service Co.*, 263 U. S. 508; *United States* v. *McFarland*, 275 U. S. 485; *Missouri-Kansas-Texas R. R. Co.* v. *Texas*, 275 U. S. 494), we note preliminarily that the first, second, and fourth reasons of the petition are grounded upon petitioner's erroneous assumption that the Court below has held that Bond merely patented a law of nature, this being the defense of petitioner which is predicated, as we have shown, upon the testimony of petitioner's experts that the Bond theory of inhibition is false. Thus each of these reasons depends upon disputed and controversial facts as disclosed by the evidence upon which the Court below decided the fact of invention adversely to petitioner. These reasons, therefore, are no more than disguised requests that this Court find the facts different from those found by the Court below. The following comments as to each of these reasons dealing with "law of nature" also show that legally they are without merit.

1. The Opinion of the Court Below Is not in Conflict With the Principles of Decisions of this Court.—The main trouble with petitioner's first reason is that the Court below found the novelty and utility of Bond's composite inoculant to reside, not in Bond's discovery of a law of nature *per se*,

but, rather, in the application and utilization by him of a law of nature in a manner previously regarded as "dangerous practice," thereby to produce a composite inoculant "successful, efficient and filling the need it was meant to fill" (R. 827). Thus, the Court held that Bond "did much more than discover a law of nature. He made a new and different composition, one contributing utility and economy to the manufacture and distribution of commercial inoculants" (R. 824). This ruling is in entire harmony with the decisions of this Court which, from *LeRoy v. Tatham, et al.*, 55 U. S. 156, to *Mackay Radio & Tel. Co. v. Radio Corp. of America*, 306 U. S. 86, 94, have consistently recognized that application of a law of nature or utilization of scientific knowledge to or in a novel and useful structure or product is patentable invention.

There is a decided difference between merely claiming the discovery of a law of nature and claiming either a machine, process, article of manufacture or composition of matter in which a natural law or force is utilized. This difference has never been ignored by this Court. Many of the most important inventions have necessarily applied or made use of an agency of nature for a practical purpose. Valuable contributions to the advancement of the arts and sciences—inventions which have changed the face of human society and civilization—have been made by simply putting a force of nature into a specified condition and then using that force in that condition for a practical purpose. He who first discovers that a law of nature can be made operative for the production of a valuable result is an inventor of the highest order, and a public benefactor. This Court has never repudiated this salutary criteria of patentable invention.

It is not necessary to examine all of the cases in this Court which have given effect to the qualification or exception to the general rule. It is sufficient to cite, as an apt

illustration, the *Telephone* cases, 126 U. S. 1, 534, where it was said:

> "In the present case the claim is not for the use of a current of electricity in its natural state as it comes from the battery, **but for putting a continuous current in a closed circuit into a certain specified condition suited to the transmission of vocal and other sounds, and using it in that condition for that purpose.** So far as at present known, without this peculiar change in its condition it will not serve as a medium for the transmission of speech, but with the change it will. **Bell was the first to discover this fact, and how to put such a current in such a condition, and what he claims is its use in that condition for that purpose,** just as Morse claimed his current in his condition for his purpose."

So in the case at bar, the Bond composite inoculant involved the use of one of the agencies of nature for a practical purpose. The patentable invention which has been upheld is one which involved the inventive conception of putting a force of nature into a certain specified condition and then using it in that condition for a practical purpose.

In *LeRoy* v. *Tatham et al.*, this Court qualified the general rule upon which petitioner relies when it said (55 U. S. 175) that "A new property discovered in matter, when practically applied, in the construction of a useful article of commerce or manufacture, is patentable," and quoted the following sound pronouncement from *Household Co.* v. *Nielsen*, Websters Pat. Cases, 683:

> "A patent will be good, though the subject of the patent consists in the discovery of a great, general, and most comprehensive principle in science or law of nature, **if that principle is by the specification applied to any special purpose, so as thereby to effectuate a practical result and benefit not previously attained.**"

The ruling of the Court below upholding the Bond patent is based precisely upon the foregoing qualification of the general rule. This is shown unanswerably by the following quotation from Judge Lindley's opinion when, in speaking of Bond's patented inoculant, he said (R. 824):

> "... This was application of scientific knowledge to things existing in nature and the utilization of them in a desirable composite product which had not been previously achieved but which he did achieve and of which the public now has the benefit."

It is quite unnecessary to consider at length the other decisions of this Court cited by petitioner in support of its first reason, as none of them modifies the fundamental rules established by *LeRoy* v. *Tatham* and the *Telephone Cases* with which the opinion below is in harmony. Thus, *O'Reilly* v. *Morse*, 56 U. S. 62, merely held that Morse's eighth claim was "too broad, and not warranted by law," and, together with *Le Roy* v. *Tatham*, establishes the rule that a principle, function or result, without more, may not be patented. *Rubber-Tip Pencil Co.* v. *Howard*, 20 Wall. 498, invalidated a patent for a rubber head for pencils which merely showed making the hole in the rubber head smaller than the pencil to be inserted in the hole. It was admitted by this Court that a new device by which an idea is made *practically useful* is patentable. Petitioner's quotation from *Burr* v. *Duryee*, 1 Wall. 531, 570, is taken from this Court's discussion of the scope to be given to Wells's machine patent as influenced by the then statutory requirement that a patentee set forth in his specification "the principle and the several modes in which he has contemplated the application of that principle." This Court, of course, concluded that the inventor of a machine improvement cannot have a claim to the "whole art, discovery, or machine which he has improved." *Smith* v. *Nichols*, 21 Wall., 112, 119, stands only for the proposition that a mere

change in degree is not patentable invention. *Corona Co.* v. *Dovan Corp.*, 276 U. S. 358, was really concerned with whether one Kratz or the patentee Weiss was the first discoverer of a certain vulcanization accelerator, this being the issue on which different circuits had disagreed thereby resulting in the case being brought here. Claims 1, 4 and 9 of the patent appear to have been invalidated also on the ground that they related to an entire group of compounds without any showing having been made that there was a general quality common to all members of the group. In *De Forest Radio Co.* v. *General Electric Co.*, 283 U. S. 664, the Langmuir patent on the high vacuum discharge tube was invalidated upon the basis of prior publication by one Lilienfeld. It was claimed for Langmuir that the prior tube was not practical, but this Court ruled that such contention was inadmissible and that the question at hand was essentially whether the earlier workers had showed "how it could be made and demonstrated and disclosed the relationship of the discharge to reduced pressure, and how to reduce it.".

When a new and different product, of benefit to the public, is produced by application of a law of nature, it cannot be denied that such an invention or discovery is entitled to the protection of our patent system. The opinion of the Court below upholding the Bond patent in suit is in harmony with the principles of decision which have been formulated by this Court. On the actual facts as found by the Court below, there is no need for any exposition by this Court of these well-settled rules of the patent law.

2. The Opinion of the Court Below Is not in Conflict With Decisions of Other Circuit Courts of Appeals.—It having been demonstrated that the decision of the Court below is in harmony with the applicable rules of decision of this Court, it follows that if there is conflict among the

circuits, as averred in the second reason of the petition, this is not the case in which to resolve the conflict and the departure from the decisions of this Court has been made by circuits other than the Seventh Circuit. However, petitioner's discussion of the second reason is so grossly misleading that we are compelled to make a brief reply to it.

It is averred by petitioner that there is a conflict between the Seventh Circuit Court of Appeals and the Ninth Circuit Court of Appeals; it is claimed that the Honorable Evan A. Evans, Senior Circuit Judge of the Seventh Circuit, extrajudicially admitted in a speech made by him, that *Dennis et al.* v. *Pitner et al.*, 106 F. (2d) 142, which was cited and followed in the case at bar, is opposed to and in conflict with *Vitamin Technologists, Inc.* v. *Wisconsin Alumni Research Foundation* (C. C. A. 9), 146 F. (2d) 941.

In fairness to Judge Evans, it must be noted that the opinion of the Ninth Circuit Court of Appeals, with which Judge Evans disagreed in his remarks delivered before the Pittsburgh Patent Law Association, is not the final opinion reported at 146 F. (2d) 941. It is most misleading and unfair to say that Judge Evans publicly announced that in *Dennis et al.* v. *Pitner et al.*, the Court below had reached a conclusion opposed to that announced in the *Vitamin* case without explaining that Judge Evans was then referring to the Ninth Circuit opinion, which was rendered on June 30, 1943, and "suddenly withdrawn" on petition for rehearing. That opinion is reported only in 58 U. S. P. Q., 293.

In the first opinion filed in the *Vitamin* case, the Ninth Circuit Court of Appeals, on the authority of its earlier decision in *Wall* v. *Leck*, 66 Fed. 552, invalidated the Steenbock patent as being an attempt to monopolize a natural process. Thus the court said (58 U. S. P. Q. 295):

> ". . . Steenbock's valuable scientific certitudes are discoveries, but they are not inventions within the

meaning of the term 'invention' as used by the Congress in its patent laws. This court so determined in one of the able opinions of District Judge Hawley in Wall v. Leck, 66 F. 552 (CCA-9)."

On reconsideration, however, a majority of the Ninth Circuit Court of Appeals reversed themselves on the law of-nature defense and said (146 F(2d) 949):

"D. The Patents Are Not Invalid Because in the Process of Preparing Foods for Exposure of Their Activatable Lipoids and Their Exposure to the Ultra Violet Rays of the Sun or Lamp Is Utilized the Natural Force of Sunlight or a Force Like It From the Lamp.

"Appellant also argues that the patents seek a monopoly of the ultra violet rays of the sun or lamp, a natural force, and are hence invalid under our decision in Wall v. Leck, 9 Cir., 66 F. 552. **We do not agree.**"

Thus, there is no difference between the views of the Ninth and Seventh Circuit Courts of Appeals. Judge Evans disagreed with the first, or withdrawn, opinion in the *Vitamin* case. No one has ever claimed that he disagrees with the present opinion, which is in accord with the decisions of this Court, with *Dennis* v. *Pitner*, and with the opinion of the Court below in the instant case.

It is also asserted by petitioner that the decision of the Court below is in conflict with the case of *Morton* v. *New York Eye Infirmary*, 17 Fed. Cas. 879, 881, this being cited as a "C. C. A. 2" decision (Petitioner's Brief, p. 29), evidently to mislead this Court into believing that the decision was rendered by the Circuit Court of Appeals for the Second Circuit. Actually, this decision was rendered by the Circuit Court of New York, and not by the Second Circuit Court of Appeals, and does not, according to our understanding of the certiorari practice, present the type of

conflict which warrants the issuance of the writ. The *Morton* case, however, recognizes the exception to the general rule, and expressly points out that where the inventor has laid hold of a law of nature and connected it with some particular medium or mechanical contrivance, "by which, or through which, it acts on the material world, . . . he can secure the exclusive control of it under the patent laws." This is precisely the reasoning applied by the Court below in upholding the Bond patent in suit.

It is next claimed that the decision of the Court below is in conflict with the decision of the Fourth Circuit Court of Appeals in *Novocol Chemical Mfg. Co., Inc.* v. *Powers & Anderson Dental Co., Inc.*, 128 F. (2d) 904, 907. In that case, all that the patentee had done was to satisfy himself that the cause of discoloration of epinephrin was oxidation, and not contact with the rubber or glass of the containers used, and he sought a patent upon the idea of enclosing the epinephrin cartridges in an air-tight can. In these circumstances, it was held that there did not seem to be any "great originality of thought" to conclude that "some air was reaching the solution" in the previous attempts to produce air-tight cartridges. Thus, the court said (907):

> "The remedy was obvious and one of long practice, consisting merely in putting the product in an air-tight container for the purpose of preventing contact with the air."

In the case at bar, it is abundantly established that the remedy or solution constituting Bond's invention was not obvious; neither was it one of long practice, as was true in the *Novocol* case. The *Novocol* case and the instant case are entirely different. Each has been properly decided on its own facts, and the very most that can be said of these two cases is that the courts on different facts have reached different results. These different results were of necessity

inevitable because of the legal requirement that each case be decided on its own particular facts.

It is also urged that the decision of the Court below is in conflict with many decisions and particularly those of the First, Third, and Sixth Circuits, in cases cited on pages 8 and 9 of the petition. We wish to note that no Third Circuit cases have been enumerated in the petition, and in the absence of a discussion by petitioner of the alleged conflicting First and Sixth Circuit cases, there is no need for a detailed discussion of the decisions. We are content to observe that a careful examination of all the cases cited fails to reveal any conflict among the circuits.*

There is thus no occasion to resolve in this case any real conflict between the Circuit Courts of Appeals. We have failed to find any difference of opinion among the courts as to the proper application of the rules of decision formulated by this Court. The results reached in all of the cases are reconcilable, and there is no conflict among the courts of the sort which the prior decisions of this Court have held were essential to move it to grant a writ of certiorari.

3. The Inoculant Disclosed in the Bond Patent in Suit Is Properly Classifiable as a Composition of Matter. The Claims in Suit are not Invalid Merely Because Bond's Inoculant Makes Useful Application of a Law of Nature.— The fourth reason of the petition is a restatement of the first reason in slightly different form, and constitutes a re-

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* *Katz* v. *Horni Signal Mfg. Corporation* (C. C. A. 2), 145 F. (2d) 961, does not support petitioner's contentions and is, indeed, an excellent example of the reckless character of petitioner's assertion that the case at bar is in conflict with the ordinary rule. It is to be noted that the patent in the *Katz* case was sustained as being for a device which made "a **highly useful application** of one of Faraday's discoveries." Counsel apparently refer to a single sentence which appears by way of preliminary introduction in the opinion of the court, an abstraction with which we have no quarrel, namely, that discoveries of mere general scientific laws, *without more*, are unpatentable.

argument by petitioner of its falsely conceived defense that the Bond patent merely describes and claims the discovery of a law of nature. Petitioner contends that there can be no patentable invention "when the discoverer does nothing but use the natural phenomena or attribute in its natural form, without change. . . ." There is absolutely no warrant for this restrictive and unreasonable construction of our patent laws. Certainly the decisions cited by petitioner do not support it. The true rule is that set out and recognized by this Court at an early date in *Le Roy* v. *Tatham* and restated recently in *Mackay Radio & Telegraph Co.* v. *Radio Corp. of America*, 306 U. S. 86, 94, where it was said:

> "While a scientific truth, . . . is not patentable invention, a novel and useful structure created with the aid of knowledge of scientific truth may be."

It is not required that the natural force be used in a manner other than that in which it performs in nature. It is not required that the natural force be modified or changed. All that is necessary is that the natural force be placed in a specified condition and used in that condition for a practical purpose.

That the Bond composite inoculant is a true composition of matter appears from the opinion below, thus (R. 823):

> ". . . in fact the evidence is clear that what he discovered was that certain existing bacteria do not possess the mutually inhibitive characteristics which had previously prevented a successful commercial composite inoculant and that those uninhibitive species may be successfully combined. It was this contribution of non-inhibitive strains which **successfully combine** that brought about **a new patentable composition.**"

As used in the patent statute (R. S. 4886, 35 U. S. C. § 31), the words "composition of matter" only presuppose a combination of elements except, of course, that novelty,

utility and invention are required. The phrase "covers all compositions of two or more substances. It includes all composite articles whether they be results of chemical union or of **mechanical mixture** . . . " (Walker on Patents, Deller's Ed.) Section 14, page 55. See also *Keasbey & Mattison Co.* v. *Philip Carey Mfg. Co.* (C. C. New York), 139 Fed. 571, 573; *Union Carbide Co.* v. *American Carbide Co.* (C. C. A. 2), 181 Fed. 104, 106-7; *J. E. Baker Co.* v. *Kennedy Refractories Co.* (C. C. A. 3), 253 Fed. 739.

Actually, in presenting its fourth reason, petitioner is contending that no invention was made by Bond in the production of his composite inoculant.* When petitioner asserts that Bond did nothing more than use a natural phenomenon or attribute in its natural form without change, for the same purpose it performs in its natural habitat in an old way, petitioner is arguing a question of fact decided adversely to petitioner by the Court below. Thus, the Court below said (R. 827):

> "'. . . an inventive concept may reside in the selection of a part or parts of numerous old elements. If the selection is unusual and a hitherto unsolved problem is overcome, it answers the tests of the statute and, in the absence of other limiting features, will achieve invention. So here Bond did a novel thing in the science of culture of bacteria to inoculate leguminous plants. . . . 'Thus he taught how to make a composite inoculant, successful, efficient and filling the need it was meant to fill. . . . It is inventive conception."

Nor is the decision in this case in conflict with *American Fruit Growers, Inc.* v. *Brogdex*, 283 U. S. 1. That case involved the classic unsuccessful attempt to patent a natural

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*This is emphasized by petitioner's reliance on *Hotchkiss* v. *Greenwood*, 11 How., 248, and *Cuno Engineering Corp.* v. *Automatic Devices*, 314 U. S. 84, which do not in any way involve discussions of the patentability of a law of nature; they were concerned only with the question of invention on the particular facts in those cases; see particularly 11 How., 267.

orange, and is wholly inapposite to the facts of the case at bar. That decision in no way forbids the grant of a patent for a new and useful composition of matter utilizing a natural force for a practical purpose. It was merely held by this Court that the addition of borax to an orange did not produce any change in its name, appearance, or general character, and hence that the claims of the patent did not relate to a "manufacture," as that term had been defined by previous decisions of this Court. No attempt was made by this Court in the *Brogdex* case to annul the qualification to the general rule deducible from *Le Roy* v. *Tatham* and the *Telephone* cases. This, of course, is apparent from the restatement of the qualification to the rule in *Mackay Radio & Tel. Co.* v. *Radio Corp. of America*, 306 U. S. 86, 94. It cannot be said of Bond's composite inoculant, which, as found by the Court below, was new and different and one contributing utility and economy to the manufacture and distribution of commercial inoculant and which achieved an end theretofore unobtainable, as it was said of the orange in the *Brogdex* case, that there had been no change in name, appearance or general character of the subject matter involved. This is the vital difference between *Brogdex* and this case.

II.

THE SEED INOCULANT INDUSTRY IS NOT CONCENTRATED IN OR SUBJECT TO THE SEVENTH CIRCUIT. NO QUESTIONS OF IMPORTANCE TO THE PUBLIC AS DISTINGUISHED FROM THE PARTIES ARE INVOLVED IN THIS CASE.

The third and fifth reasons set forth in the petition do not bear careful examination and when properly considered present no grounds for the allowance of the writ.

On petitioner's own admission there are, in addition to Agricultural Laboratories, Inc., of Columbus, Ohio, three other seed inoculant manufacturers located beyond the territorial limits of the Seventh Circuit, *viz.*:

1. *Nelson Laboratories, Stockton, California.*

2. *Earp-Thomas Laboratories, Inc., Bloomfield, N. J.*

3. *Strassburger & Siegel, Baltimore, Md.*

The affidavit of Myron E. Lusk, annexed hereto as an appendix (*post*, p. 28), shows that there is another manufacturer to be added to this list, *i.e.*:

4. *Pearson and Company, Mobile, Alabama.*

Thus there are seed inoculant manufacturers located in the Third, Fourth, Fifth, and Ninth Circuits, and clearly it cannot be said that there is no probability of litigation on the Bond patent in circuits other than the Seventh, and that there is no probability of conflict among the circuits regarding the Bond patent.

Petitioner asserts that the companies beyond the Seventh Circuit are small ones doing a local business only, and less than ten per cent of the total. But these assertions are not verified and no facts and figures are given from which the correctness of the assertions may be ascertained. Moreover, not only does the Lusk affidavit show the inaccuracy of petitioner's assertions, but it also establishes that Pearson and Company, the seed inoculant manufacturer which was omitted from the petition, is an important factor in the industry, doing a considerable and substantial business. Mr. Lusk, of course, frankly and honestly admits that he is unable to give the volume of his competitors' business in dollars and cents, but nevertheless on the basis of his experience in and knowledge of the industry, he has stated that the percentage figures advanced by petitioner are not correct.

Certiorari was granted in the *Schriber-Schroth* case and in *Exhibit Supply Co.* v. *Ace Patents Corp.*, 315 U. S. 126; *Muncie Gear Works, Inc.* v. *Outboard Marine & Mfg. Co.*,

315 U. S. 759; and *Williams Mfg.* v. *United Shoe Mach. Co.*, 316 U. S. 364, upon showings of a concentration of the industry involved in the circuit which had upheld the patent. Such a showing has not been made in the instant case. There is sharp disagreement between the parties as to the number of inoculant manufacturers located beyond the Seventh Circuit, and the proportion of the total business in and outside that circuit, while wholly irrelevant, is in serious question.

Nor is this case of any greater public and national interest than any other ordinary patent case. Petitioner's assertion that the decision of the Court below vitally affects "fundamental research" and other industries is lacking in basis on the record, for it is assumed again by petitioner, for purposes of this "*in terrorem*" argument, that the Court below has held that a mere discovery of a law of nature is patentable, an assumption which we have abundantly demonstrated to be an erroneous and unwarranted distortion of the opinion of the Court below.

Petitioner's assertion, moreover, that the Bond patent "monopolizes the present methods of raising clover, alfalfa, soy beans, etc., throughout the nation" is not supported, nor could it be, by citation of the record. The record shows that at the time Bond entered the field, the inoculant industry was manufacturing and selling only *single* cultures for field seeds such as clover, alfalfa, and soy beans (R. 142). Since that time only two manufacturers, in addition to respondent, have adopted Bond's mixed culture (R. 147). Respondent still sells single cultures for soy beans (R. 147). Dr. Erdman testified that his company does not produce a mixed culture for alfalfa and clover (R. 237). While the Bond mixed culture is a distinct step forward, and offers important economic advantages in the manufacture and distribution of inoculants, it does not render prior single cultures obsolete, nor does the patent "monopolize . . . an old method of agriculture."

III.

THE BOND CLAIMS DEFINE THE NEW PRODUCT DISTINCTLY AND EXACTLY: THEY FULLY MEET THE REQUIREMENTS OF THE STATUTE (R. S. 4888).

Petitioner's sixth reason is made superficially plausible only by completely ignoring the nature of the patented product. The opinion of this Court in *Halliburton Oil Well Cementing Co.* v. *Walker*, 329 U. S. 1, deals with patent claims to a machine comprising a plurality of old and readily describable elements. The case of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, to which this Court referred in the passage quoted by petitioner, dealt with product claims and specifically recognized the difficulties that may be encountered in defining the essential qualities of a product and that exceptions to this Court's strict prohibition against the use of functional terms may be desirable in order to meet the requirements of the statute.

The product of the Bond patent involves bacterial life which is customarily described and classified by its physiological characteristics; *i.e.*, what it will do. Thus the clover bacteria, *Rhizobium trifolii*, are distinguishable from the alfalfa bacteria, *Rhizobium meliloti*, not by their physical characteristics, but by the *effect that they have* on clover plants and alfalfa plants. So here, non-inhibitive strains ("alpha" strains) do not differ from inhibitive strains in physical characteristics. As the Court below said (R. 826):

> "There is no weight and measure method by which he (the scientist) may determine the quality or quantity of bacteria . . ."

There is nothing in the statute itself that militates against the use of physiological characteristics to distinctly define the claimed invention, nor has this Court held that a statement of the physiological characteristics is objectionable as "functional." The claims of the Bond

patent define the product with precise exactness in language that cannot be misunderstood and are not subject to the vice of the claims considered by this Court in the *General Electric* case *supra*. There the court said (p. 371):

> "The claim uses indeterminate adjectives which describe the function of the grains to the exclusion of any structural definition, and thus falls within the condemnation of the doctrine that **a patentee may not broaden his product claims by describing the product in terms of function.**"

Here there is no broadening, but rather a definite limiting of the claims, by reciting the non-inhibitive character of the bacteria.

Again in the *General Electric* case, this Court said (p. 371):

> "A limited use of terms of effect or result, which accurately define the essential qualities of a product to one skilled in the art, may in some instances be permissible and even desirable, but a characteristic essential to novelty may not be distinguished from the old art solely by its tendency to remedy the problems in the art met by the patent. And we may doubt whether the language used in Claim 25, taken by itself, conveyed definite meaning to those skilled in the art of incandescent lighting."

There can be no doubt that the language of the Bond claims conveys an exact and definite meaning to those skilled in the inoculant art.

Finally this Court in the *General Electric* case recognized the specific exemption accorded by Congress to plant patents, saying (p. 372, footnote 13):

> "Different considerations may apply under the Act of May 23, 1930, c. 312, § 2, 46 Stat. 376, 35 U. S. C. § 33, providing that no 'plant patent shall be declared invalid on the ground of non-compliance with this sec-

tion if the description is made as complete as is reasonably possible'."

Although the Bond patent is not a plant patent and thus not strictly subject to the exception, the impossibility of describing, other than by their physiological characteristics, living bacteria which differ only in these characteristics, is analogous to the difficulties of plant description recognized by Congress and should be likewise recognized where, as here, the claims clearly fix the limits of the invention.

CONCLUSION.

Petitioner's attack in the Courts below upon the validity of the Bond patent in suit consisted chiefly of the "law of nature" defense which in turn depended upon the testimony of petitioner's experts that the theory of the Bond patent is false and that noninhibitive bacterial strains do not exist: in other words, that Bond's composite inoculant is not new, different or inventive, but is no more than an exemplification of a law of nature and how it works, Bond adding nothing thereto. The trial court made a specific finding of fact as to the existence of Bond's noninhibitive strains, and thus rejected the testimony of petitioner's experts. Such testimony was urged again upon the Circuit Court of Appeals, and upon an examination of all the evidence that court refused to disturb the trial court's findings. Although petitioner has presented the "law of nature" issue as a broad legal one, it is really one of fact and dependent upon acceptance of the twice rejected testimony

of petitioner's experts. Hence, as this Court said in *Bodkin* v. *Edwards*, 255 U. S. 221, 223:

> "The case as presented here turns essentially on questions of fact. Both courts below on a review of the evidence have found the facts in the same way. This court under a settled rule, accepts such concurring findings unless clear error is shown."

The decision below is correct. It is in accord with applicable decisions of this Court and is not in conflict with decisions of other Circuit Courts of Appeals. This case, moreover, does not involve any principles, settlement of which is of importance to the public as distinguished from the parties.

It is respectfully submitted that the petition for a writ of certiorari should be denied.

Respectfully submitted,

J. Bernhard Thiess,
Sidney Neuman,
M. Hudson Rathburn,
Counsel for Respondent.

APPENDIX

IN THE

Supreme Court of the United States

OCTOBER TERM, 1947

No. 280

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

AFFIDAVIT OF MYRON E. LUSK

STATE OF ILLINOIS }
COUNTY OF ADAMS } ss:

MYRON E. LUSK, being duly sworn, deposes and says:

I am President and General Manager of Kalo Inoculant Company, respondent in the above-entitled case, and have been engaged in the inoculant business for over fifteen years. I am familiar with the inoculant business in the United States and with the inoculants produced by substantially all of the manufacturers thereof.

I am familiar with the United States Department of Agriculture publication Circular 724, referred to on page 31 of petitioner's brief, and with similar publications of this

same character. It is my undertsanding that these publications do not purport to present a report on the condition of the inoculant industry, but merely report on the products that have been purchased by field representatives and tested by the Department of Agriculture during specified periods. To my knowledge the list of manufacturers given in the said Circular 724 is not complete for the years 1943-1944, for the reason that it omits two companies that were, to my knowledge, manufacturing legume inoculants during the period which the circular purports to cover. Certainly, it cannot be accepted as presenting a complete picture of the inoculant industry at the present date.

The list of manufacturers beyond the Seventh Circuit presented on pages 31 to 33 of petitioner's brief, fails to mention Pearson and Company of Mobile, Alabama, which company manufactures legume inoculants and is a substantial factor in the industry.

While no published information is available as to the actual volume of business done by the industry as a whole or by individual manufacturers, I have made a careful analysis based on my knowledge of the business done by the Kalo Inoculant Company in various parts of the country and on information received from jobbers and others whom I consider reliable.

On the basis of this analysis I do not agree with the statement in petitioner's brief that the "companies in the Seventh Circuit plus Agricultural Laboratories, Inc., do well over 90% of the business." Based on reliable information that I have received relative to the quantities of raw materials that are being purchased by Pearson and Company, and on my knowledge of how the inoculant business is conducted, I can state that this company is a substantial factor in the inoculant industry and is buying for a production that would equal 10% of the business in the industry.

Based on the experience of Kalo Inoculant Company, respondent herein, I believe that over 75% of the total inoculant business done by companies located in or subject to the Seventh Circuit, consists of two single culture inoculants for two legumes that normally are not grown in the same parts of the country. Consequently these two single culture inoculants are never handled in substantial quantities by the same dealers, and the Bond mixed culture therefore has no economic application to these. If this volume of business is eliminated, the companies outside the Seventh Circuit would, to the best of my belief, rate with the companies in or subject to the Seventh Circuit and would thus represent approximately one-third of the business to which the Bond patent relates.

The inoculant industry as a whole is a small industry, and it is my belief that the total sales of the eleven companies which today make up this industry, amounted to substantially less than three quarters of a million dollars for the year 1946. Furthermore, all of the companies in the industry are small companies. The Kalo Inoculant Company, respondent herein and owner of the Bond patent, is I believe at least second or third in the industry in volume of sales. This company is capitalized for only Sixteen Thousand Dollars ($16,000.00) and maintains a payroll that varies from a minimum of 7 employees to a maximum of only 19, depending upon the season of the year.

MYRON E. LUSK,

Subscribed and sworn to before me this 3rd day of September, 1947.

WALTER A. MEIDBREDER,
Notary Public

My commission expires September 28, 1947.

SEAL

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IN THE

SUPREME COURT OF THE UNITED STATES

OCTOBER TERM, 1947

No. 280

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

RESPONDENT'S REPLY.

Petitioner's Reply Brief conclusively establishes that petitioner is here seeking a review of fact questions decided adversely to petitioner by the Court below, and that the false issue presented by the Petition is predicated on an erroneous assumption that constitutes a misinterpretation and distortion of the opinion of the Court below* (Respondent's Br. p. 1).

We are content to rest our characterization of the issue as presented in the Petition on the restatement thereof contained in petitioner's Reply Brief (p. 1). Although this restatement now concedes (1) that the issue does not involve broadly the "law of nature" point stated in the

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* In the case of *Missouri-Kansas-Texas Railroad Company* v. *Texas*, 275 U. S. 494, cited by petitioner (Reply Br. p. 1), this Court vacated the granting of the writ because "the grounds advanced for the granting of the writ prove, upon an examination of the record, not to have a substantial basis" (Respondent's Br. p. 10).

petition, but instead involves a fact question, i. e., the truth of Bond's theory of inhibition (Respondent's Br. pp. 2, 8), petitioner persists (2) in its refusal to acknowledge that the Court below expressly found that the patentee "did much more than discover a law of nature" (Respondent's Br. p. 1).

Petitioner correctly quotes (Reply Br. p. 2) the holding of the Court below, but to support its "law of nature" point ignores the requirement for "application of that quality in a successful combination which is of value to mankind." Petitioner bases its case on the assumption, which its own quotation establishes as erroneous, that the Court below broadly held that "the discovery of a natural phenomenon or of a quality or attribute of a well known article . . . is entitled to patent protection." As stated in our main Brief, this is a distortion of the opinion of the Court below.

Petitioner's reply (pp. 3 and 4) challenges our statement of the problem solved by Bond. Again this is a question of fact which the Court below decided adversely to petitioner, saying (R. 822):

> "This problem had not been solved by any one and it apparently daunted Bond, for, at first, it appeared insoluble. . . . His scientific investigation led to a proper solution, which we think the evidence shows had baffled the workers in the prior art because of their mistaken assumption of supposedly universal inhibitive effect encountered in mixed cultures."

Petitioner's long footnote (Reply Br. pp. 4, 5) again seeks a determination of a fact question, saying: "We leave it to the Court whether Kronenberger . . . or Petitioner's experts . . . will be believed." The question of the credibility of petitioner's experts was decided ad-

versely to petitioner by the District Court and was concurred in by the Court of Appeals (Respondent's Br. p. 8).

Petitioner (Reply Br. pp. 6-8) has not met our analysis of the two decisions of the Ninth Circuit Court of Appeals in the *Vitamin Technologists, Inc.*, case, nor the relation of these two decisions to *Dennis* v. *Pitner* (Respondent's Br. pp. 14-16). At most, petitioner has shown that Judge Healy, who wrote special concurring opinions in both decisions of the case, did not change his position on the law of nature defense. Petitioner cannot show that the majority of the court did not, as we have demonstrated, reverse its position on the law of nature defense.

In any event, it is immaterial here whether the *Vitamin Technologists* case is in conflict with *Dennis* v. *Pitner* as interpreted by petitioner, because the decision of the Court below in this case did not hold that a mere discovery of a law of nature constitutes patentable subject matter. On the contrary, the different results reached in this case and in the *Vitamin* case arose from the different facts involved. In the second opinion in the *Vitamin* case, it was held that the Steenbock patents, while not merely directed to a "law of nature," were anticipated by the prior art. The Court below held that the Bond patent was directed to *much more* than a law of nature; was not anticipated by the prior art (R. 825); arose to the dignity of invention (R. 827); and disclosed "a new patentable composition" (R. 824).

The additional quotation from Walker on Patents presented in petitioner's reply (p. 8) confirms the fact that the Bond inoculant constitutes a patentable composition of matter. The "different or additional property" which the Bond inoculant possesses is its ability to fix nitrogen in leguminous plants of more than one cross inoculation group with the same efficiency as single inoculants utilizing the same strains. None of the several ingredients, i. e., the

separate species of bacteria, individually possesses this ability." Furthermore, the Bond mixed inoculant was not "a well known substance."

Petitioner concedes (Reply Br. p. 9) that the rule of *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, and *Halliburton Oil Well Cementing Co.* v. *Walker*, 329 U. S. 1, is avoided if the claim language is "limiting" in character. We have demonstrated (Respondent's Br. pp. 24-26) that the language employed in the Bond claims is aptly descriptive of the physiological characteristics of the bacteria, aptly distinguishes over the prior art, and clearly fixes the limits of the invention.

The affidavit of Miles M. Elmers (Reply Br. pp. 11-15) and petitioner's reargument (Reply Br. pp. 5 and 6) merely confirm respondent's position that there is sharp disagreement between the parties with respect to the *proportion* of the total inoculant business inside and outside the Seventh Circuit (Respondent's Br. pp. 21-23) and do not deny that there are at least four manufacturers of inoculants located in three circuits other than the Seventh. Clearly the rule applied in *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 305 U. S. 47, is not applicable here.

Respectfully submitted,

J. Bernhard Thiess
Sidney Neuman
M. Hudson Rathburn
Counsel for Respondent.

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CHARLES ELMORE CROPLEY

IN THE

Supreme Court of the United States

OCTOBER TERM, 1947.

No. 280

FUNK BROTHERS SEED COMPANY,
Petitioner,

vs.

KALO INOCULANT COMPANY,
Respondent.

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SEVENTH CIRCUIT.

BRIEF FOR RESPONDENT.

J. BERNHARD THIESS,
SIDNEY NEUMAN,
M. HUDSON RATHBURN,
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THE BUNTHORP-WARREN PRINTING COMPANY, 310 WEST JACKSON, CHICAGO

INDEX.

	Page
Opinions Below	1
Jurisdiction	2
Questions Presented	2
Statement	4
The Bond Patent in Suit	5
The Subject Matter—Leguminous Plants and Legume Bacteria	5
Commercial Inoculants	7
(a) Single Inoculants	8
(b) Mixed Inoculants	9
The Bond Invention	12
The Disclosure of the Patent in Suit	13
The Controversy Between the Experts as to Nature of Bond's Improvement and the Theory of the Patented Invention	15
The Mixed Inoculants Defined by the Claims of the Bond Patent Are New	18
The Opinion of the Court Below	21
Summary of Argument	26
Argument	31
Introduction	31
I. The Bond Patent in Suit Does Not Merely Disclose and Claim the Discovery of a Law of Nature	36
(a) The Bond Product Is New and Useful and Possessed of the Quality of Invention	43
(b) The Patentable Application of a Discovery of a Law of Nature Is Not Dependent Upon Modification or Change of the Natural Force or Agency; Nor Is It Dependent on Use in a Manner or for a Function That Is Not Accomplished in Nature	48
(c) The Inoculant Disclosed in the Bond Patent Is Properly Classifiable as a Composition of Matter	55
(d) The Vitamin Technologists Case Is Not Parallel to the Facts in This Case	60
II. Patent Claims That Define a New Bacteriological Product Distinctly and Exactly in the Only Language Available to the Art, Fully Meet the Requirements of the Statute and Are Not Invalid as Being Functional	63
III. Public Importance Is Not a Ground for Invalidating an Otherwise Valid Patent	71
Conclusion	74
Appendix	75
Pertinent Statutes	75

CITATIONS

Cases:

Adamson v. *Gilliland*, 242 U. S. 350 32
Altoona Publix Theatres, Inc. v. *American Tri-Ergon Corp.* 294 U. S. 477 46
American Fruit Growers, Inc. v. *Brogdex*, 283 U. S. 1 59
J. E. Baker Co. v. *Kennedy Refractories Co.* (C. C. A. 3), 253 Fed. 739 ..... 53, 55
The Barbed Wire Patent, 143 U. S. 275, 283 ..... 33, 46
Bates v. *Coe*, 98 U. S. 31 43
Battin v. *Taggert*, 17 How. 74, 85 33
Bischoff v. *Wethered*, 9 Wall. 812, 814 33
Boston Pencil Pointer Co. v. *Automatic Pencil Sharpener Co.* (C. C. A. 2), 276 Fed. 910, 912 ..... 43, 44
Cameron Septic Tank Co. v. *Village of Saratoga Springs* (C. C. A. 2), 159 Fed. 453 ..... 39, 40, 49
Collar Company v. *Van Dusen*, 23 Wall. 530 43
Consolidated Safety-Valve Co. v. *Crosby Steam Gauge & Valve Co.* 113 U. S. 157, 179 46
Continental Paper Bag Co. v. *Eastern Paper Bag Co.*, 210 U. S. 405, 416, 422 32
Crown Cork & Seal Co. v. *Gutmann Co.*, 304 U. S. 159, 161 2
DeForest Radio Co. v. *General Electric Co.*, 283 U. S. 664 52
Dennis et al. v. *Pitney et al.* (C. C. A. 7), 106 F. (2d) 142 24
Diamond Rubber Co. v. *Consolidated Tire Co.*, 220 U. S. 428, 435 47
E. I. Du Pont de Nemours & Co. v. *Glidden* (C. C. A. 2), 67 F. (2d) 392, 397 47
Eibel Co. v. *Paper Co.*, 261 U. S. 45, 60 ..... 33, 35
Expanded Metal Co. v. *Bradford*, 214 U. S. 366, 381 47
General Electric Co. v. *DeForest Radio Co.* (C. C. A. 3), 28 F. (2d) 641 54
General Electric Co. v. *Wabash Appliance Corp.*, 304 U. S. 364 ..... 30, 64, 68
General Talking Pictures Corp. v. *Western Electric Co.*, 304 U. S. 175, 179 2
Goodyear Co. v. *Ray-O-Vac Co.*, 321 U. S. 275 ..... 32, 47
Guaranty Trust Co. of New York v. *Union Solvents Corp.* (D. Del.), 54 F. (2d) 409 (Aff'd per curiam (C. C. A. 3), 61 F. (2d) 1041) (Cert. denied, 288 U. S. 614) 68
Halliburton Co. v. *Walker*, 329 U. S. 1, ... 25, 30, 64, 65, 66, 67, 68, 70
Hartford-Empire Co. et al. v. *United States*, 323 U. S. 386, 432 ..... 30, 71
Holland Furniture Company v. *Perkins Glue Company*, 277 U. S. 245 ..... 63, 64, 68

Hotchkiss v. Greenwood, 11 How. 248, 266 48
Houschill Co. v. Neilson, Webster's Patent Cases, 683 ..... 37, 50
Imhaeuser v. Buerk, 101 U. S. 647, 660 43
Katz v. Horni Signal Mfg. Corp. (C. C. A. 2), 145 F. (2d) 981. (Cert. denied, 324 U. S. 882) 40
Keasbey & Mattison Co. v. Philip Carey Mfg. Co. (C. C. N. Y.), 139 Fed. 571, 573 55
Keller v. Adams-Campbell Co., 264 U. S. 314, 319 73
Kuehmsted v. Farbenfabriken of Elberfeld Co. (C. C. A. 7), 179 Fed. 701, 705 56
Layne & Bowler Corp. v. Western Well Works, 261 U. S. 387, 393 .. 73
LeRoy et al. v. Tatham et al., 55 U. S. 156 ..... 26, 36, 37, 51
LeRoy et al. v. Tatham et al., 63 U. S. 132 37
Loom Co. v. Higgins, 105 U. S. 580, 581 33
Mackay Radio & Tel. Co. v. Radio Corp., 306 U. S. 86 ..... 24, 40
Morton v. New York Eye Infirmary (S. D. N. Y. 1862), 17 Fed. Cas. 881 51
National Battery Co. v. Richardson Co. (C. C. A. 6), 63 F. (2d) 289, 292 56
New York Trust Company v. Eisner, 256 U. S. 345 46
Novocol Chem. Co. v. Powers & Anderson Dental Co. (C. C. A. 4), 128 F. (2d) 904, 907 55
Old Town Ribbon Co. v. Columbia Co. (C. C. A. 2), 159 F. (2d) 379, 382 48
O'Reilly et al. v. Morse et al., 56 U. S. 62 ..... 36, 52
Parke-Davis & Co. v. H. K. Mulford Co. (C. C. N. Y.), 189 Fed. 95, 103 56
Radio Corp. of America v. Radio Engineering Lab., Inc., 293 U. S. 1, 8 33
Riter-Conley Mfg. Co. v. Aiken (C. C. A. 3), 203 Fed. 699, 702 (Cert. Denied, 229 U. S. 617) 69
Rubber-Tip Pencil Co. v. Howard, 20 Wall. 498, 507 48
Sewall v. Jones, 91 U. S. 171 38
Seymour v. Osborne, 11 Wall. 516 45
Sharpless Co. v. Crawford Farms, 287 Fed. 655, 658 59
Smith v. Nichols, 21 Wall. 112 ..... 45, 48, 52
Standard Brands, Inc. v. National Grain Yeast Corp., 308 U. S. 34 .. 69
Stilz v. United States, 269 U. S. 144, 147 33
The Telephone Cases, 126 U. S. 1, 534 ..... 38, 49, 51, 72
Thomson Spot Welder Co. v. Ford Motor Co., 265 U. S. 445 33
Toledo Pressed Steel Co. v. Standard Parts, Inc., 307 U. S. 350, 356 48
Ex parte Tullar et al., Appeal No. 6999, decided Sept. 9, 1947 (Pat. Off. Board of Appeals) 71

Union Carbide Co. v. *American Carbide Co.* (C. C. A. 2), 181 Fed. 104 ..... 53, 54, 3
United States v. *Moore*, 95 U. S. 760 6
Universal Winding Co. v. *Foster Mach. Co.* (D. C. Mass.), 16 F. Supp. 671 5
Vitamin Technologists, Inc. v. *Wisconsin Alumni Research Foundation* (C. C. A. 9), 146 F. (2d) 941 ..... 29, 42, 61, 6
Washingtonian Publishing Co. v. *Pearson*, 306 U. S. 30 6
Williams Co. v. *Shoe Machinery Corp.*, 316 U. S. 364, 369 ..... 32, 45, 4
Wintermute v. *Redington* (C. C. Ohio, 1856), 1 Fish. Pat. Cas. 239, 30 Fed. Cas. 367 3

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Sec. 47, pp. 254-5 ..... 43, 4

IN THE

Supreme Court of the United States

OCTOBER TERM, 1947.

No. 280

FUNK BROTHERS SEED COMPANY,

Petitioner,

vs.

KALO INOCULANT COMPANY,

Respondent.

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SEVENTH CIRCUIT.

BRIEF FOR RESPONDENT.

OPINIONS BELOW.

The opinion of the Circuit Court of Appeals (R. 817-833) is reported in 161 F. (2d) 981.

The District Court did not render an opinion but merely filed a brief memorandum of holdings (R. 744-5), which is unreported. Its findings of fact and conclusions of law will be found beginning at page 745 of the record.

JURISDICTION.

The Judgment of the Circuit Court of Appeals was entered June 12, 1947 (R. 834). The petition for a writ of certiorari was filed August 19, 1947, and granted October 13, 1947 (R. 840).

The jurisdiction of this Court is conferred by Section 240(a) of the Judicial Code, as amended by the Act of February 13, 1925 (28 U. S. C. § 347).

QUESTIONS PRESENTED.

This is an ordinary patent infringement case which involved in the courts below the usual issues of validity and infringement of respondent's patent No. 2,200,532, issued May 14, 1940, to Bond, and entitled "Bacterial Inoculant for Leguminous Plants."

Petitioner did not present any questions in its petition for a writ of certiorari in respect of the concurrent findings of infringement made against it by the courts below,* and hence, the single issue before this Court is whether respondent's patent is valid under the patent statutes R. S. §§ 4886 and 4888 (35 U. S. C. §§ 31, 33)**—invalidity being urged by petitioner upon the grounds (1) that the decision of the Court of Appeals offends a rule of decision that forbids the patenting of a law of nature, and (2) that the claims in suit depend upon functional statements and hence are of a sort condemned in recent decisions of this Court.

In posing the issue, petitioner purports to challenge only the rule of law followed by the court below (Br. p. 3); but

* Therefore, no infringement questions are before the Court. *Crown Cork & Seal Co. v. Gutmann Co.*, 304 U. S. 159, 161; *General Talking Pictures Corp. v. Western Electric Co.*, 304 U. S. 175, 179.

** The provisions of these sections are reproduced in an Appendix, *post* p. 75.

in its statement and in its argument petitioner wholly ignores the facts as found in this case and, by means of assertions based on testimony and evidence rejected by the court below, misinterprets and distorts the opinion of that court. The questions actually presented are these:

(a) Where the facts, as found by the courts below, establish that a successful composite or mixed inoculant had long been prevented by the inhibitive effect exerted on each other by certain strains of legume bacteria, and that the patentee has discovered the existence in nature, contrary to universal belief, of both inhibitive and non-inhibitive strains of the bacteria, and has applied and utilized this scientific knowledge by selecting and combining only noninhibitive strains in the production of a highly useful and desirable product of which the public now has the benefit, did the Circuit Court of Appeals improperly apply to these facts the rule of law that application of scientific knowledge in a successful combination which is of value to mankind is entitled to patent protection? And

(b) Where the subject matter of a patent pertains to a product employing bacterial life which is customarily described and classified not by its physical characteristics but instead by its physiological characteristics, *i.e.*, what it will do, are patent claims which specify, as completely as it is reasonably possible, such physiological characteristics, objectionable under the patent statutes?

STATEMENT.

Petitioner's statement of the case reflects only the view of the facts and the evidence which petitioner advanced in the District Court and which was rejected both by the trial judge and by the court below. It misstates the nature of the Bond invention and of the prior art and is in sore need of supplementing and correcting.

Respondent sued petitioner in the United States District Court for the Southern District of Illinois (R. 2-5) for infringement of respondent's patent No. 2,200,532, for a "Bacterial Inoculant for Leguminous Plants," which was issued May 14, 1940, to respondent upon an application filed August 24, 1938, by Varley Sherman Bond (R. 770-779).

The case was tried in part on formal admissions of petitioner, and in part on oral and documentary evidence. Upon final hearing, the District Court found, "with reluctance,"—it being impressed with "the very great diligence" and "ingenuity" of the patentee and "with the results obtained"—that the claims in suit, although infringed by petitioner, were invalid because not relating to any improvement which could be classified under any of the subjects covered by the Patent Act (R. 744). Accordingly respondent's action was dismissed (R. 754). On respondent's appeal, the court below concurred in the finding that petitioner was guilty of infringement (R. 827-831), but reversed the District Court on validity because it was felt that on the trial judge's own findings it was "obvious" that the patentee had made "an inventive step forward in the art," and that the trial judge had misconceived the legal effect of the undisputed evidence and of his findings of fact made on a conflict in testimony (R. 823-824). As will hereafter more particularly appear, the courts below have concurrently found that the statutory

prerequisites of utility, and ingenuity, exist; and whereas the District Court did not expressly consider and therefore made no finding as to the third prerequisite, *i.e.*, novelty, *the court below has found and petitioner now concedes* (Br. p. 4, footnote 4) *that this fact also exists.*

The case is here on a writ of certiorari to the Circuit Court of Appeals for the Seventh Circuit to review that court's opinion upholding the validity of respondent's patent (R. 817-827).

THE BOND PATENT IN SUIT.

The invention of the Bond patent in suit may be described in nontechnical language as a product adapted to be applied to seeds by farmers prior to planting, for increasing the growth or yield of certain crops, and for increasing, or minimizing the depletion of, the amount of nitrogen compounds contained in the soil. The product (an inoculant) is not a fertilizer; it is not added to the soil; instead it is applied directly to the seeds and infects the plant roots.

The Subject Matter—Leguminous Plants and Legume Bacteria.—For the purposes of this case it may be accepted that the various crops that are important in agriculture fall into two main classes: First, leguminous plants such as alfalfa, clover, beans, peas, etc. (R. 35), and, second, nonleguminous plants such as grasses or grains. Leguminous plants or legumes, as they are sometimes called, are characterized by their ability under certain conditions to take atmospheric nitrogen directly from the air and convert it into organic nitrogenous compounds that are beneficial to plant growth. This is known as "fixing" atmospheric nitrogen (R. 38). Nonleguminous plants do not have this characteristic but instead depend for their nitrogen requirements solely upon the nitrogenous compounds

such as nitrates or ammonium salts that may be present in the soil (R. 37).

It has long been known that the ability of leguminous plants to fix nitrogen from the air depends on the presence of certain bacteria which infect the roots of the plant and form small lumps or nodules (R. 36).* Although the exact mechanism by which nitrogen fixation is accomplished is not known, it is an accepted fact that unless these "root nodules" are formed on the plant roots by the bacteria the plant is unable to fix nitrogen from the air (R. 29 and 30). The growth and protein content of leguminous plants depend, in nitrogen deficient soil, on the amount of nitrogen taken from the atmosphere by the plant.

The "root nodule" bacteria or "legume" bacteria, as they are sometimes called, exist in nature as a plurality of distinct species and it is recognized that any one species will not infect or form nodules on the roots of all species of leguminous plants. Certain species of root nodule bacteria are specific to certain groups of leguminous plants, and a group of plants that will be infected by a single species of bacteria is known as a cross-inoculation group (R. 748, Findings 9 and 10). There are at least six well recognized species of root nodule bacteria which will respectively infect six fairly well defined cross-inoculation groups (R. 39 and 40).** Each species of root nodule

* The plants and the bacteria are said to grow in "symbiotic" relation.

** In bacteriological terminology the root nodule bacteria are known as the genus *Rhizobium*, the six species of bacteria and the corresponding cross-inoculation groups of leguminous plants being:

Species	Cross-inoculation Group
Rhizobium trifolii	Red clover, crimson clover, mammoth clover, alsike clover
Rhizobium meliloti	Alfalfa, white and yellow sweet clovers
Rhizobium phaseoli	Garden beans
Rhizobium leguminosarum	Garden peas and vetch
Rhizobium lupini	Lupines
Rhizobium japonicum	Soy beans

bacteria is made up of innumerable distinct strains of bacteria which vary in efficiency, that is, the ability of the bacteria to beneficially affect the plant to which they are specific (R. 31, Admissions 19 and 20).

Although root nodule bacteria are widely present in nature they are not universally present in all soils and it has become the accepted and desirable practice, in order to insure the presence of a sufficient number of efficient bacteria of the proper species, to inoculate the seeds of the leguminous plants prior to planting with artificial cultures or inoculants. By the use of efficient inoculants, the farmer obtains a substantial increase in the crop yield. Typical increased yields of clover due to artificial inoculation are shown in respondent's Exhibit No. 6 (R. 378).

Commercial Inoculants.—The first step in the preparation of a commercial culture or inoculant is the preparation of so-called stock strains, which may be preserved for long periods of time under properly controlled laboratory conditions. The stock strain comprises a single strain of the desired species of bacteria which has been isolated from nature, identified as to species, and tested for efficiency.*

Once having obtained a satisfactory supply of efficient stock strains, the technical problems involved in the manufacture and sale of reliable commercial inoculants reduce to, first, the necessity of supplying the bacteria to the farmer in a readily usable form for application to the seeds prior to planting, and second, the necessity of insuring that the bacteria are present at the time the product is used in such numbers and in such live and active condition that the plants will be thoroughly inoculated.

* The isolation, selection, and testing of stock strains of bacterial cultures and the preparation of commercial inoculants are fully described in Mr. Bond's testimony (R. 39-48).

In general, the bacteria are incorporated in a suitable base or carrier which will enable the farmer to apply the bacteria to the seeds with a minimum of trouble. The base or carrier must be of a character such that the bacteria will remain alive and active from the time of incorporation in the base until the time of application to the seeds (R. 149). Bacteria, being living organisms, will not remain alive and active in a commercial inoculant indefinitely, and it is the usual practice in the industry to indicate on each package an expiration date beyond which the inoculant should not be used. This expiration date is usually one year from the date of packaging of the product (R. 53).

(a) Single Inoculants.—Prior to the Bond invention it was the general practice in the inoculant industry to manufacture and sell for use by the farmer only so-called single cultures or single inoculants (R. 142 and 147). Each inoculant contained only one species of root nodule bacteria and accordingly could be employed successfully only on the plants of the particular cross-inoculation group corresponding to this species. Thus in order to supply inoculants to an agricultural area wherein the principal crops include clover, alfalfa and soy beans for example, it was necessary for the dealer to maintain a stock of clover inoculant, a separate stock of alfalfa inoculant and a separate stock of soy bean inoculant. Commercial inoculants are packaged in three sizes, *i.e.*, sufficient to inoculate ½ bushel, 1 bushel, or 2½ bushels of seeds. In addition to requiring larger inventories, this practice of supplying single inoculants resulted either in an inadequate supply of inoculants for the farmer toward the end of the planting season or in loss to the dealer and the manufacturer if sub-

stantial stocks of the inoculant were left over at the end of the planting season* (R. 140-141).

(b) Mixed Inoculants.—A mixed or composite inoculant, as distinguished from a single inoculant, contains root nodule bacteria of two or more species and may be used by the farmer to inoculate leguminous crops of more than one cross-inoculation group.

To a layman it would seem, as it did to the early workers in the inoculant art, that the provision of a mixed culture would offer no problems over and above those involved in the provision of a single culture. Certainly the mere step of including one or more additional species of root nodule bacteria in the usual single culture would appear to offer no technical problems. Experience, however, prior to the Bond patent, was directly to the contrary.

As early as 1907 the advantages of mixed cultures were recognized and explained (see Earp-Thomas patent No. 865,965, DX 20, R. 784, lines 6-18, R. 785, lines 57-76). During the ensuing decade various mixed inoculants were advertised for sale accompanied by glowing promises and extravagant claims as to beneficial results, but these products without exception were failures and disappeared from the market.** Strains of bacteria which functioned with high efficiency when used in single cultures, became inefficient when mixed with other species in a mixed culture. The undisputed evidence shows (R. 142) that there were

* Although over-age stock could, under the general practice in the industry, be returned to the manufacturer for a 50% refund, the trouble involved and the loss both to the dealer and to the manufacturer was a major source of annoyance in the industry and the advantages of supplying a mixed culture or inoculant were recognized very early in the history of the art.

** There is not a shred of evidence in this case to show, for example, that the products advertised by the Homewood Nitrogen Company in 1914 (R. 636) or the Alphano Humus Company in 1916 (R. 609) were ever sold or used.

no mixed cultures for field legumes on the market at the time the product of the Bond patent was first introduced to the trade. Prior to the Bond invention mixed inoculants had fallen into disrepute. They were considered impractical and were not offered for sale in competition with single cultures.*

The "Bible" of the inoculant industry (R. 125), published in 1932 and entitled "Root Nodule Bacteria and Leguminous Plants" by Edwin Broun Fred, Ira Lawrence Baldwin and Elizabeth McCoy, University of Wisconsin Studies, states at page 244 (PX 13, R. 398), that "composite cultures offer few advantages and certainly many disadvantages," and at page 254 (R. 401) that "it is desirable to have only the one type of organism in the culture."**

The scientific investigations into the efficiency of mixed cultures and the causes of the failure of mixed cultures to provide the same degree of nitrogen fixation as single cultures all pointed toward the impracticability, or even impossibility, of producing a mixed culture which would have the same ability to promote nitrogen fixation when applied to leguminous plants as would a plurality of single cultures containing the same strains of bacteria. The deficiency of mixed cultures was ascribed to an inhibitive effect

* Mr. Bond testified (R. 137):

"The results obtained with these cultures were very uncertain. Sometimes they didn't even form nodules on the plants for which they were recommended. In other words, the need for a mixed culture was shown in the early history of these mixed cultures but none of them survived on the market, to my knowledge anyway, much after 1930 when there were more intensive culture tests made by the State and the United States Government institutions."

** Petitioner's implication (Br. p. 7) that mixed cultures offered no difficulties beyond those encountered with single cultures is not supported in the record. The quotation from Fred, Baldwin & McCoy, in petitioner's footnote 12, is immediately followed by the recommendation of these eminent scientists that only single cultures be employed.

exerted by the different species of bacteria on each other which reduced the efficiency of the bacteria.* In other words, although the different species of bacteria were found to be capable of living together, they would for some reason not function as well in association with each other as when used alone.

The apparently insurmountable inhibitive effect encountered in mixed cultures was not the only difficulty involved in the preparation of a satisfactory product. It had long been known that the different species of root nodule bacteria were characterized by different rates of growth, some being very fast growers and some being very slow. Accordingly, placing two or more species of root nodule bacteria in a nutrient rich base, as had been suggested and taught in the prior patents and literature,** would result in the faster growing species overgrowing the slower ones to the extent that by the time the product was to be used there would be either a deficiency or a complete absence of the slower growing species of bacteria in the purported mixed culture. Dr. Erdman, one of petitioner's experts, commented on this problem in a report dated June 10, 1938, in which he criticized and undertook to demonstrate the impracticability of the Bond mixed cultures which had just been introduced to the trade by respondent. Thus Erdman

* The most extensive investigation of this inhibitive effect made prior to the Bond invention is found in a report by Max Kronberger of the Bavarian Agricultural Institute for Plant Culture and Plant Protection, Munich, Germany (R. 383-394). See particularly Kronberger's conclusion (R. 394). See also the report of the Department of Agriculture for the Dominion of Canada by Dr. Lockhead (R. 396, last 7 lines).

The Kronberger report is based on experiments which extended over a period of four months, and the Lockhead report is an official publication of the Canadian government. Surely these are not "more or less casual statements" (Petitioner's brief p. 13) and they were neither "refuted or explained" by petitioner's witnesses.

** See Earp-Thomas patent 1,099,121 (R. 786, lines 87-91).

pointed out that reliance on growth of the bacteria after mixing with the base, as had been done in single cultures, would lead to disaster. This comment was made prior to issuance of the Bond patent which teaches the use of a low nutrient base and the initial incorporation of large numbers of each species.*

The Bond Invention.—The inventor, Mr. Bond, when initially assigned the problem of developing and producing a satisfactory mixed culture or inoculant for farmers, conducted an exhaustive survey of the then available literature (R. 54 and 55).

The problem faced by Mr. Bond was two-fold: first, the elimination or correcting of the mutually inhibitive effect, and second, insuring that the final product would contain the proper number of live and active bacteria of each species throughout the intended useful life of the product. The solution of this apparently insoluble problem by Mr. Bond stems from the startling and unheralded discovery that there exist in nature certain strains of each species of root nodule bacteria which do *not* exert a mutually inhibitive effect on each other and that such mutually noninhibitive strains can by proper methods of selection and testing be isolated for use in mixed cultures, and in the conception by Mr. Bond that a final product which would contain

* Erdman said (R. 145):

"Another factor, which might seriously interfere with the efficiency of such a culture is the rate of growth of the different legume bacteria. We believe that **most manufacturers of humus legume inoculants depend upon the increased growth of the legume bacteria after they are mixed with the humus. It would be almost suicidal** to mix a slow growing organism like the soybean bacteria with fast growers like the alfalfa and red clover bacteria. Such a culture if prepared, say in January, would theoretically contain relatively few soybean bacteria when it would be used on soybeans in May or June." (Emphasis ours, throughout unless otherwise noted.)

throughout its expected life a sufficient number of live and active bacteria of each species could be achieved by employing a base material substantially free of nutrients and by initially adding to this base material large numbers of each species of bacteria, the number of each species being of substantially the same order of magnitude (R. 103).

The Disclosure of the Patent in Suit.—The Bond patent sets forth clearly and in meticulous detail the nature and the characteristics of leguminous plants and legume bacteria (R. 773, col. 1, line 5, to col. 2, line 8); the recognized classification of the *Rhizobia* and the legumes into corresponding species and cross-inoculation groups (R. 773, col. 2, line 31, to R. 774, col. 1, line 5); the prior art practices in connection with single cultures (R. 774, col. 1, lines 6 to 69); the general belief in the art as to the undesirability of mixed cultures (R. 774, col. 1, line 70, to col. 2, line 7); and the disadvantages attending upon the use of single cultures (R. 774, col. 2, lines 8 to 33). The patent states the object of the invention to be, among others (R. 774):

> "* * * to provide a mixed culture of *Rhizobia* capable of inoculating the seeds of plants belonging to several cross-inoculation groups and having the **same efficiency** in respect to nitrogen fixation as a culture which contains only a single species of the organism."

A preferred method of preparing humus type cultures is described in complete detail in the patent (R. 774, col. 2, line 67 to R. 776, col. 1, line 24). The principal advantage of this preferred method of preparation lies in its application to mixed cultures, since as the patent points out (R. 776, col. 1, lines 25 to 38), the number of organisms initially incorporated into the humus base may be accurately determined and the final culture is comparatively free of excess nutrients, such as sugar and minerals which are to a large extent retained in the agar or jelly.

The two-fold problem which Mr. Bond overcame and which had baffled the workers in the prior art is set forth in the patent as involving the inhibitory effect between certain strains of the different species of bacteria and the difficulties in the production of the culture wherein the presence of a sufficient number of each species of bacteria is insured (R. 776, col. 1, lines 63 to 71). The magnitude of the inhibitory effect that may be encountered in mixed cultures is emphasized in the patent by reference to actual tests wherein a strain of soy bean bacteria (*Rhizobium japonicum*) was found to produce 34.8% more nitrogen when employed alone on soy bean seeds than when employed on soy bean seeds in the presence of clover bacteria and alfalfa bacteria (*Rhizobium trifolii* and *Rhizobium meliloti*); and wherein a strain of clover bacteria was found to produce 118% more nitrogen when employed alone than when employed in the presence of soy bean bacteria and alfalfa bacteria (R. 776, col. 2, lines 3 to 56).

The prior belief in the art as to the inhibitory effect encountered when different species of root nodule bacteria are mixed together in a common base is referred to in various passages throughout the patent, and the discovery of the existence of noninhibitive strains and the procedure for selecting such noninhibitive strains are clearly delineated (R. 776, col. 2, lines 64 to 68, and 777, col. 1, lines 9 to 35).

The mutually noninhibitive strains discovered by Mr. Bond are for convenience arbitrarily designated in the patent as "alpha" strains (R. 777, col. 1, lines 36-61). A specific test for determining an alpha strain, which clearly indicates the advantages of using only selected alpha strains in mixed cultures, is recited in the patent (R. 778, col. 1, line 25, to col. 2, line 16).

The large number of bacteria of each species initially introduced into the low nutrient base and the proportionate

number of each species preferably employed are emphasized in the specific example given in the patent (R. 777, col. 2, line 33, to R. 778, col. 1, line 15). The culture used as an example in the patent is a three-in-one culture for inoculating clover, alfalfa, and soy bean plants, and the proportions set out are 300 million clover bacteria per cubic centimeter, 300 million alfalfa bacteria per cubic centimeter, and 450 million soy bean bacteria per cubic centimeter. The importance of this aspect of the Bond invention (the low nutrient base and initial introduction of large numbers of bacteria) which eliminates the danger of one species of bacteria overgrowing the others is explained (R. 778, col. 2, line 68, R. 779, col. 1, line 4).

The Controversy Between the Experts as to Nature of Bond's Improvement and the Theory of the Patented Invention.—Petitioner's principal attack upon the validity of respondent's patent was a so-called "law of nature" defense which was predicated upon petitioner's assertion that the theory of the patent was false, which in turn was based upon the testimony of petitioner's experts that they did not believe in the theory of inhibition. The entire premise of petitioner's defense was that inhibitive strains of bacteria either *do not exist* or *are such a rare exception* as to be unimportant in the manufacture of mixed cultures. It followed, contended petitioner, that Bond discovered nothing, "for his alleged discovery is based on a false theory," and that the patent in suit had been procured as the result of deliberate misrepresentations to the Patent Office as to the character of Bond's product, and therefore actually disclosed and claimed no more than a law of nature.

The patentee Bond and respondent's experts, Dr. Umbreit and Dr. Burris, presented testimony directly opposed to that of petitioner's experts, and hence the question whether or not inhibitive and noninhibitive strains exist in

nature, together with its necessary corollary whether the patent in suit merely disclosed and claimed a law of nature as urged by petitioner, was a question of fact to be determined upon a conflict in the testimony and upon the credibility of witnesses.

The trial judge, after seeing and hearing the experts on both sides, agreed with the patentee and with respondent's experts, Dr. Umbreit and Dr. Burris, that the theory of the patent in suit is true, and found from the evidence that Bond had discovered the fact that among the bacteria found widely spread in nature there existed both mutually inhibitive and mutually noninhibitive strains (Finding No. 14, R. 750).

The court below refused to disturb this finding of fact, saying (R. 820):

> "* * * he (the trial judge) made a specific finding that Bond did discover that there exist in nature noninhibitive strains and that these noninhibitive strains may be selected, isolated and combined and still perform satisfactorily their ordinary desirable functions. Upon this finding there was controverted evidence, but our examination of the record is convincing that that supporting the finding is rather conclusive and that there is no justification for us to declare * * * error in making it."

There is abundant support for these concurrent findings. Thus the patent in suit gives actual test results that establish the existence of both the inhibitive strains, which prior workers in the art had found, and the noninhibitive strains, discovered by Mr. Bond (R. 776, col. 2, lines 3-56). Bond testified (R. 73) that the results given in the patent are based on actual tests. In addition to the tests for inhibition reported in his patent, Bond tested twenty-two mixed cultures and he found fourteen cases of inhibition (tests U 2-38, R. 78 and 79; U 3-38, R. 79; and U 1-40, R. 79, 82-83).

Respondent's expert witnesses Dr. Umbreit (R. 340) and Dr. Burris (R. 352) based their scientific opinions, that both inhibitive and noninhibitive strains of root nodule bacteria do exist, on Mr. Bond's extensive tests, on the literature, and on certain of the tests presented by petitioner's experts (R. 340-341; 352-353).

On the other side of the controversy, petitioner's experts testified, either on the basis of inconclusive tests or no tests at all, that they did not believe in inhibition. Each merely asserted a lack of belief in inhibition, and not one of these witnesses commented on or attempted to explain the Bond tests. Mr. Bond was not even asked about his tests on cross-examination, nor was he asked to produce his test data for the inspection of petitioner's experts. Consequently his tests stood uncontradicted.

The trial judge also rejected the testimony of petitioner's experts when he found for the plaintiff on the "issue of 'unclean hands'" (R. 744) and entered a finding of fact (No. 19, R. 751) to the effect that prior to Bond's invention "substantial portions of the available literature indicated that mixed cultures for field legumes were generally unsatisfactory and that different strains or species of * * * bacteria exhibited an inhibitory effect on each other when mixed in a common base," that Bond believed in the "existence of this inhibitory effect" and had acted in "good faith when he stated in his application that it had been considered impractical to prepare a composite culture inoculant * * * because it was generally believed that one species produced an inhibitory effect on another * * * whereby symbiotic fixation * * * was inhibited or even prevented."

The court below expressly considered petitioner's renewed contention that the patentee had misrepresented his improvement to the Patent Office; it re-examined the evi-

dence and concurring in the foregoing finding of fact, said (R. 825):

> "* * * We find nothing in the record to justify us in ignoring or declaring erroneous this specific finding of the District Court."

The Mixed Inoculants Defined by the Claims of the Bond Patent Are New.—Although petitioner disclaims (Br. p. 4, footnote 4) any intent to urge "anticipation by reason of the prior art," petitioner discusses at length (Br. pp. 4 to 8) the testimony and evidence which were adduced by petitioner to show anticipation and which, after being "studiously examined," were rejected by the court below (R. 824). Petitioner's equivocal contention that the mixed culture of the Bond patent (although anticipation is not urged) is not new forms the basis of its "law of nature" arguments (Points I, II, and III, Br. pp. 19-38), and consequently we deem it advisable to emphasize some of the factors which led to a rejection of petitioner's evidence, when holding that nothing "in the art suggests the slightest conception of Bond's solution of the problem", the court below said (R. 824):

> "* * * the sum total of all of the prior teaching is that mixed inoculants had been in existence before but that they had been composed by hit and run methods without regard to whether the various species included in the composite worked adversely to one another or inhibited one another in their respective growths."

There are two distinct types of tests that are commonly made in the production and control of bacterial inoculants. The *first* is the nodulation test, in which the plants are permitted to grow for a limited period only (3 to 5 weeks) and the number of root nodules observed. This test, which is also sometimes called a vegetative test, may, if the plants are grown for a somewhat longer period, provide an *indication* as to whether the bacteria are effecting stimula-

tion of the plants, but *it does not measure the efficiency of the bacteria.* It determines only that bacteria of the proper species are present (Admission 18, R. 31; Erdman, R. 231-232; Leonard, R. 298; Bond, R. 45). This is the type of test that is used by the United States Department of Agriculture (R. 298) and by various state experiment stations, including New Jersey (DX 19, R. 622, Manns, R. 269) and New York (DX 30, R. 677-678; Hofer, R. 332-333).

The *second* type of test is the efficiency test, or test for nitrogen fixation. These tests consume more time, effort, and care than nodulation tests, and are therefore less commonly used. Three methods may be employed: (a) visual observation of growth and color; (b) dry weight of harvested plants; (c) chemical analysis of dried plants for actual nitrogen content. Method (a) (visual observation) cannot be depended upon (Bond, R. 112; Burris, R. 346); method (b) (dry weights) is sufficiently accurate for most purposes; and method (c) (chemical analysis) is the only scientifically accurate test (Admission 21, R. 31).*

The most that Dr. Manns could have established in his tests (Petitioner's Br. p. 6) is that a plurality of different species of root nodule bacteria will *live and grow* together for a short time in a proper *compost or fertilizer.* Dr. Manns made no tests for nitrogen fixation (either dry weight or chemical analysis) and no tests to compare his mixed culture with single cultures using the same strains. He merely observed the roots of the plants to see whether nodules were formed (R. 254). The "strong inoculation" referred to in Dr. Manns' report (Petitioner's footnote 9) refers only to the size and number of the nodules, and the record establishes (Admission No. 18, R. 31) that "The

* Petitioner is in error (Br. p. 14) when it asserts that respondent "vigorously attacked" dry weight tests—it is only the visual inspection tests that respondent criticizes as being basically inconclusive.

size and number of the root nodules formed on the roots of leguminous plants cannot be considered a measure of the amount of nitrogen fixed." Clearly Dr. Manns' report did not advance the art or contribute any teaching useful in the production of satisfactory mixed cultures.

Petitioner ignores the distinction between mixed inoculants for field seeds employed by farmers and the so-called garden cultures which respondent concedes were sold prior to the Bond patent. These garden cultures, prepared in small packages for sale to home gardeners, usually contained a mixture of three or four different species of root nodule bacteria, so that the home gardener could use the contents of the package interchangeably on beans, peas, sweet pea flowers, or lupine flowers according to his desires (DX 3A, R. 44). These small packages, selling for 10 cents or 20 cents, were advertised for use on 5 to 12 lbs. of seed but were usually employed to inoculate the few ounces of seed contained in the standard 10-cent size package of garden seeds, and the relative efficiency of the mixed garden culture was of negligible importance.

Plaintiff's Exhibit 10 (R. 382) demonstrates the importance of inhibition in mixed cultures for field seeds, but in home gardens the production of a few more peas or beans or a few more flowers is of no particular importance, and the use of any culture, regardless of its efficiency, serves to increase the yield over that obtained when no culture is used. So far as this record shows, no one was ever sufficiently interested in the efficiency of garden cultures to test them further than to ascertain whether sufficient bacteria were present in the culture to form nodules on the plant roots. Fred, Baldwin, and McCoy, in criticizing mixed cultures (R. 398), said with respect to garden cultures (R. 398-399):

> "* * * Perhaps the only justification for this mixing of strains is in the case of the small-size garden culture

> Because of the limited amount of seed to be sown, it may be desirable to have one culture containing the organisms for such crops as beans and peas and thus to reduce the cost of inoculation."

Matchette, in his letter criticizing the mixed cultures of the Bond patent, states that such cultures had never proven successful, and draws a distinction as to garden cultures (R. 143).

The record in the case at bar shows only, and respondent concedes, that garden cultures containing more than one species of Rhizobium were sold prior to the Bond patent. It is abundantly clear, however, that these garden cultures were not and are not the mixed cultures defined in the claims of the Bond patent, and petitioner's assertions to the contrary are unavailing.

Petitioner's comparison (Br. p. 7) of the alleged method practiced in 1937 by McQueen's in making garden cultures is based solely on the *uncorroborated recollection testimony of Curie*, whom the court below characterized as an "interested witness," whose testimony, even as to more recent events, was found to be "not the most convincing," and whose views as to inhibition were declared "erroneous" (Opinion, R. 830).

Petitioner completely failed to prove its garden culture defense with the particularity required by the authorities, and it was rejected by the court below.

THE OPINION OF THE COURT BELOW.

The Circuit Court of Appeals rested its opinion upholding the validity of respondent's patent upon the well-established patent law principle that patentable invention results from the application of a discovery of a principle or law of nature to a special purpose so as thereby to effectuate a practical result and benefit not previously attained.

It thought that this principle was controlling, as it was peculiarly apposite to the facts as found by both courts below, which were to the effect that the patentee had discovered that there exist in nature noninhibitive strains of bacteria and that these noninhibitive strains may be selected, isolated and combined in a carrier and still perform satisfactorily their ordinary desirable functions in a composite commercial inoculant which had not been previously achieved and of which the public now has the benefit (Finding No. 19, R. 749, C. C. A. Op. R. 820-824).

Without elaboration of his reasons, the District Court had simply held that the Bond patent claims were invalid because they did not involve the invention or discovery of any new and useful art, machine, manufacture or composition of matter. He reached this conclusion with "reluctance," as he was impressed with the "very great diligence" and "ingenuity" of the patentee and "with the results he obtained" (R. 744). The Court of Appeals was constrained on the basis of the District Court's findings of fact and its own reexamination of the evidence to reverse this conclusion of invalidity. In view of the District Court's specific findings that Bond had discovered that there are noninhibitive strains of bacteria as well as inhibitive strains, and that Bond had been greatly diligent and ingenious, the court below thought that it became obvious that Bond had "made an inventive step forward in the art of production and commercial distribution of composite inoculants."

The Court of Appeals found the mistake of the District Court to rest in the conclusion that Bond's work did not amount to patentable invention within the meaning of the statute. In arriving at this conclusion the court below relied not only upon the trial judge's specific finding but upon its own painstaking review of the evidence which

showed: (1) that there had long been a demand "that farmers should have one composite inoculant" instead of being required to "buy, preserve and maintain several different inoculants," (2) that Bond's problem was to find a product in which "he might get away from the inhibitive antagonistic impeding characteristics of the different strains of bacteria" which when combined had rendered prior composite inoculants unsatisfactory and at the same time "produce a composite that would contain and maintain the proper number of live and active bacteria of each species throughout the useful life of the product," (3) that this problem "had not been solved by any one" prior to Bond, (4) that Bond's "scientific investigation led to a proper solution" which the evidence showed had "baffled the workers in the prior art because of their mistaken assumption of supposedly universal inhibitive effect encountered in mixed cultures," and (5) that Bond by "discovering that there are noninhibitive bacteria" had taught the art to avoid inhibitive effect as being "the restraining factor preventing a successful commercial composite inoculant" and had also taught that noninhibitive bacteria can be "successfully employed, when combined, without injury to any of the other constituent species."

The three judges of the Court of Appeals also pointed out that—whereas the District Court, despite his recognition of the value of Bond's work, thought that Bond had "merely discovered a law of nature,"—the evidence clearly showed, in their judgment, that what Bond had discovered was that "certain existing bacteria do not possess the mutually inhibitive characteristics which had previously prevented a successful commercial composite inoculant and that those uninhibitive species may be successfully combined." It was this contribution of "noninhibitive strains which successfully combine" which the three judges

of the court below believed "brought about a new patentable composition," since, as they deemed clear from the evidence, Bond had applied "scientific knowledge to things existing in nature" and utilized them "in a desirable composite product which had not been previously achieved but which he did achieve and of which the public now has the benefit."

It cannot be said that the court below intended, by its decision, to depart from the established principles of the patent law. Quite the contrary, in reaching the conclusion that the patentee's work came within the "decisive definitions of invention," reliance was placed upon, *inter alia*, this Court's decision in *Mackay Radio & Tel. Co.* v. *Radio Corp.*, 306 U. S. 86, and its own prior decision in *Dennis et al.* v. *Pitner et al.*, (C. C. A. 7) 106 F. (2d) 142. It was the view of the court below that its ruling was in accord with the doctrine of these cases because Bond's disclosure of a "successful composition of noninhibitive strains in combination of elements in one inoculant operating successfully on several different groups of legumes" established that:

> "* * * he did much more than discover a law of nature. He made a new and different composition, one contributing utility and economy to the manufacture and distribution of commercial inoculants."

Petitioner also insisted in the court below, as it indirectly urges here (Br. pp. 27-28), that the patent claims in suit do not relate to a true patentable composition of matter or combination, and that instead they are aggregative in character, covering a mixture of independent substances as found in nature, which do not lose their identity or coact to achieve a result. The major foundation of this contention was disposed of by the court below when it rejected petitioner's "law of nature" arguments. But the

court did not stop there. It also held that Bond's teaching of how to make a composite inoculant, successful, efficient and filling the need it was meant to fill, was not "aggregation," but on the contrary "inventive conception," the existence of which makes co-action unessential (R. 827). Admitting that a composite inoculant had been "thought of," the court below pointed out that just as truly it had not achieved approved recognition, and indeed was considered by scientists "a dangerous practice." The court thus concluded on this aspect of the case that because Bond had made an unusual selection, had overcome a "hitherto unsolved problem", and had exercised the inventive faculty, patentable invention of a composite inoculant had been achieved.

In overruling petitioner's argument that the "description of the patent is insufficient, under 35 U. S. C. A. 33, which requires inventors to describe clearly their inventions," the court below by clear implication also ruled that the doctrine of *Halliburton Co.* v. *Walker*, 329 U. S. 1 which had been relied on by petitioner was not offended by the claims in suit. In reaching the conclusion that there is nothing in the record to justify invalidating the patent on this score, the court below emphasized these factors:-(1) the tests to be employed in the selection of the proper bacterial strains were conventional and well known to bacteriologists, (2) noninhibitive strains are not readily identifiable in nature as separate species, (3) there is no weight and measure method by which a bacteriologist may determine the quality or quantity of his bacteria, (4) the only available method is selection by utilization of well known tests, and (5) only a scientist in his laboratory can produce controlled cultures and must at all times employ methods found efficient by trained scientists. The court consequently ruled that, as the character and limitation of

the tests prescribed by Bond were well known to the art, intelligent bacteriologists setting out properly to gather the enumerated ingredients of the composite article "could hardly go astray" on reading the description.

SUMMARY OF ARGUMENT.

It is revealed preliminarily that petitioner's discussion of that which is presented as a legal question, *i.e.*, the "law of nature" issue, is interspersed with, and bottomed entirely on, assertions of fact which are either (a) based upon testimony and evidence rejected by the courts below, or (b) inconsistent with petitioner's concession of no "anticipation by reason of prior art." Petitioner is really attempting to secure a retrial of the facts and have this Court redetermine fact questions which the courts below decided against petitioner. This Court has repeatedly held, under a settled rule, that it will not overturn concurrent findings where there is evidence to support them; and quite apart from the petitioner's concession of *no anticipation*, petitioner cannot persuasively construe the prior art evidence as it does because petitioner has wholly failed to make the clear and convincing proof which the authorities require.

I.

The facts being otherwise than as assumed and asserted by petitioner, it is quite plain that the court below did not improperly apply the law to the facts. A review of the leading decisions shows that as early as *LeRoy et al.* v. *Tatham et al.*, 55 U. S. 156, it was established that while a principle or law of nature is *per se* unpatentable, patentable invention may be achieved by the practical application of a discovery of a "new property" in matter in the "construction of a useful article of commerce or manufacture" or by

application of a discovery "to any special purpose so as thereby to effectuate a practical result and benefit not previously attained." The general rule relied on by petitioner is thus subject to an important *patentable* exception—one which entitles an inventor to patent protection for putting a natural force or agency into a specified condition and then using that force or agency in that condition for the achievement of a new and useful improvement. It was this well-settled principle of the patent law which the court below found peculiarly apposite and, therefore, controlling in the special facts of this case.

A. The Bond product is new and useful and has the quality of invention. (1) The finding of the court below that the Bond product is "new and different" is fortified by petitioner's concession of *no anticipation*, which fully implies that prior to Bond's patent there was no mixed inoculant like, or substantially like, Bond's. (2) Usefulness within the meaning of the statute is not seriously denied, and, in any event, is covered by concurrent findings which are clearly supported by the evidence. (3) That the Bond product resulted from the exercise of *invention*, thus meeting the third statutory prerequisite, is abundantly shown by the evidence. All of the criteria of invention are found in the record here. The advantages and desirability of a mixed culture for field seeds were recognized as early as 1907. Others had tried and failed to produce such culture, so that when Bond entered the field, there were no commercial mixed inoculants for field seeds on the market, and those skilled in this art condemned them as unsuccessful or "dangerous practice." Bond disabused the art of a misconception which was the very foundation of a thirty-year failure, and took the last step which turned failure into success. The trial court found that Bond was diligent and ingenious, and the court below found that he had taken

an inventive step forward in the art and that his teachings amounted to inventive conception. These findings of fact are not erroneous; they are supported abundantly by the evidence.

B. The statutory conditions of novelty, utility, and invention being met, the patentable application of a discovery of a law of nature is not dependent upon modification or change of the natural force or agency; neither is it dependent on a use of the agency in a manner or for a function that is not accomplished in nature. An examination of the decisions relied on by petitioner reveals no support whatever for petitioner's contention that patentable invention was not achieved by Bond because he did not change the bacteria or use them for a function foreign to their natural function. As man is incapable of changing the immutable laws of nature, all that is necessary is that a natural agency be placed in a specified condition and used in that condition for a practical purpose. This is precisely what Bond did in the case at bar.

C. The inoculant disclosed in the Bond patent is properly classifiable as a "composition of matter" within the meaning of the patent statute (R. S. § 4886, 35 U. S. C. § 31). The words of the statute cover all compositions of two or more substances. They include all composite articles whether they result from chemical or mechanical mixture. Bond's inoculant meets all the tests for determining true compositions. It is a combination of different elements which, by reason of a *negative* interrelationship in a whole complex, utilized as a unit, achieves a new and characteristic result. For every practical purpose it is a new thing, yielding something to the useful arts. Where the inventive step lies in the provision of a *negative* rather than a *positive* condition, and where, indeed, this was the desideratum itself, it is both illogical and absurd to contend

as does petitioner, that a true composition was not achieved merely because of the absence of positive interaction or because the elements do not lose their identity.

D. The *Vitamin Technologists* case (C. C. A. 9), 146 F. (2d) 941, is not parallel to the facts in this case. In that case, earlier scientists had succeeded, prior to Steenbock's patent, in producing antirachitic activation by application of ultraviolet rays to various substances, and Steenbock being familiar with this work, merely determined the scientific principles involved. Bond, on the other hand, did not merely determine the reasons for successful use of prior mixed inoculants, for there were no such inoculants either described or used. The *Vitamin* case expressly recognizes the rule of law which was applied by the court below. The different results in the cases are attributable to different facts. Steenbock's process was found to be anticipated, whereas here petitioner does not even urge anticipation of Bond's product. The contention that the unsuccessful prior mixed inoculants would, if used today, infringe Bond's patent must be repelled because petitioner has wholly failed to prove that the prior mixtures contained noninhibitive strains, and therefore, cannot be heard to say that Bond merely recognized a scientific truth employed by earlier workers.

II.

Patent claims that define a new bacteriological product distinctly and exactly in the only language available to the art fully meet the requirements of the patent statute (R. S. § 4888, 35 U. S. C. § 33) that a patentee "particularly point out and distinctly claim" the improvement which he claims as his invention or discovery. Thus, since bacterial life is customarily described by its physiological characteristics, *i.e.*, what it will do, Bond's claims which so describe the

bacteria are not invalid as being functional under the doctrine of *Halliburton Co.* v. *Walker*, 329 U. S. 1. The vice of the claims which this Court has condemned under the statute in that case and in others lies not in mere use of functional language, but rather in the failure of the claims to depict the invention with specificity and in the consequent extension of the monopoly beyond the real invention. In *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, it was expressly recognized that functional language *per se* is not proscribed by the statute. Where, as here, when dealing with bacterial life, physiological description rather than physical description is the tool of the art, it should not be held that use of the tools of the art, even though of a functional character, is violative of the statute. No criticism of the Bond disclosure was voiced by any expert witness. No one had any difficulty in reading the patent and understanding the nature of the Bond product as described and claimed by means of the physiological characteristics of the bacteria.

III.

Public importance is not a ground for invalidating an otherwise valid patent. Where the statutory conditions of patentability prescribed by Congress have been fulfilled, no court may disregard such compliance and deprive the patent owner of the benefits sanctioned by the Constitution on the ground that it is unwise or prejudicial to the interests of the public. *Hartford-Empire Co.* v. *United States*, 323 U. S. 386, 432.

ARGUMENT.

INTRODUCTION.

Although petitioner purports to present as the principal issue in this case the question whether there has been a proper application of the law to the facts, its arguments plainly show that petitioner's real position is that the error committed by the court below was one of fact and not of law.

Petitioner thus begs its own issue when it obscures and confuses the question actually presented by incorporating in its discussions of legal points, assumptions or statements to the effect:

(a) that the theory of the Bond patent is false—that inhibitive strains do not exist (Pet. Br. pp. 9, 13, 14, 15 and 20); and

(b) that mixed inoculants producing the same function and achieving the same result as Bond's patented inoculant were old and well known—that Bond did not create a composition of matter which had never existed (Pet. Br. pp. 22, 23, 25, 29, 30, 31, 33 and 35).

Only by assuming and relying upon such premises as (a) and (b) has petitioner succeeded in imparting any plausibility whatever to otherwise untenable arguments.

But the courts below have concurrently found the fact to be that Bond discovered, contrary to universal belief, that there exist in nature noninhibitive strains of legume bacteria and petitioner concedes that there is no anticipation by prior art. Thus in making its arguments petitioner is (a) pressing upon this Court the evidence of petitioner's experts that the Bond theory is false, which

was twice rejected by the courts below, and (b) urging points and construing the evidence as to prior art uses and patents in a manner wholly inconsistent with the concession of no anticipation. Petitioner is really seeking a retrial of the facts. It is manifest also that petitioner would have this Court overturn concurrent findings below and redetermine the fact-questions of anticipation, utility, and inventiveness.

(a) In the finding of fact that Bond discovered the existence of noninhibitive strains, it is implicit that an important discovery which in turn made possible the production for the benefit of the public of a patentably and commercially new product was made by Bond. From this finding inescapably follows the conclusion that petitioner is in error when it argues that Bond discovered nothing and exercised only the skill of the calling, or that there was no problem solved by Bond, or that the Patent Office should not have granted the Bond patent, or that Bond's inoculant is no more than a product found in nature, or that the bacteria of Bond's inoculant produce the same and well-known function of an old and well-known product.

These aspects of petitioner's argument thus turn essentially on questions of fact decided adversely to petitioner. But petitioner has not demonstrated that the concurrent finding is clearly erroneous; it is content merely to assert on the basis of its experts' rejected testimony that Bond's theory is false. This Court has repeatedly held under a settled rule that it will not overturn concurrent findings where there is evidence to support them, *Williams Co.* v. *Shoe Machinery Co.*, 316 U. S. 364, 367; *Continental Paper Bag Co.* v. *Eastern Paper Bag Co.*, 210 U. S. 405, 416, 422; *Adamson* v. *Gilliland*, 242 U. S. 350, or that it must be a strong case before this Court will do so, *Goodyear Co.* v. *Ray-O-Vac Co.*, 321 U. S. 275, 278. See also *Battin*

v. *Taggert*, 17 How. 74, 85; *Bischoff* v. *Wethered*, 9 Wall. 812, 814; *Thomson Spot Welder Co.* v. *Ford Motor Co.*, 265 U. S. 445; *Stilz* v. *United States*, 269 U. S. 144, 147.

(b) It is implicit in petitioner's concession of no anticipation by prior art that if, as the court below expressly found, the Bond mixed inoculant is new and different, which means that it is not foreshadowed by any prior art patent, publication or use, then it is not true, as petitioner despite its concession continues to assert, that (1) the bacteria work in Bond's inoculant as they worked in previous unsuccessful mixed inoculants, (2) Bond's inoculant differs from the old mixed inoculant only in degree, (3) the Bond product produces the "same and well known function" of an old and well-known product, or (4) the Bond product is the same as the prior mixed garden culture.

Irrespective of its concession, petitioner cannot persuasively urge these points in this Court because petitioner wholly failed to make the clear and convincing proof of the prior art practices and uses on which it relies, which under well-settled rules it was required to make. *Radio Corp. of America* v. *Radio Engineering Lab., Inc.*, 293 U. S. 1, 8; *The Barbed Wire Patent*, 143 U. S. 275, 284; *Loom Co.* v. *Higgins*, 105 U. S. 580, 581; *Eibel Co.* v. *Paper Co.*, 261 U. S. 45. It is well-settled that proof of prior uses must be made with reasonable clearness, and the burden of proof being upon the infringer, every reasonable doubt will be resolved against him.

The evidence clearly shows, contrary to petitioner's assertions, that the patents, publications and uses from which petitioner draws some of the assumptions which are interspersed in the discussion of the legal point, do not justify such assumptions. The evidence reveals that mixed field cultures, although previously proposed, had not

been satisfactory and had disappeared from the market, and that workers in the art had neither appreciated nor solved the problems which Bond overcame in transforming mixed cultures from general disrepute to general acceptance. This record contains a long parade of failures from and after 1907 in the attempts to place a field seed mixed culture upon the market, and this is true notwithstanding that sufficient knowledge was apparently possessed with which to prepare single cultures for field seeds, as well as with which to prepare the garden seed variety mixed culture.

Garden cultures were and are satisfactory for their intended purpose regardless of the question of inhibition, because of the different economic problems involved (*ante*, pp. 20-21). But no conclusions unfavorable to the Bond product may be drawn from the use of the garden type of mixed culture. The failure of those working in the field seed art, reinforced by their knowledge of mixed garden cultures, to adapt single field seed cultures to the preparation and use of a mixed field seed culture, indicates conclusively that the adaptation was not obvious and that it involved more than mechanical skill. It demonstrates, also, that there is a signal difference *in kind* between a mixed culture for field seeds and either the single culture or the garden variety mixture. Granting that single cultures and mixed cultures of the garden variety type had long been known, it is nonetheless clear on this record that a *different problem* was involved in the production of a field seed mixture. A most intimate familiarity, experience, and working knowledge with and of single cultures and garden mixtures had significantly failed to reveal the secret of the ways and means of producing a mixed culture for field seeds such as clover, alfalfa, soy beans, etc.

There is not one iota of proof as to the use of non-inhi-

bitive strains in garden cultures prior to the Bond invention, nor is there sufficient proof to establish that these cultures contained the various species of bacteria in numbers of substantially the same order of magnitude, or that the base employed was substantially free of bacterial nutrient. Not a single witness called by defendant even purported to have made nitrogen fixation tests for the purpose of determining whether the prior garden cultures contained noninhibitive strains.

Curie is the only witness who claimed to have made any comparative tests between single cultures and mixed garden cultures utilizing the same strains of bacteria, and his purported tests were merely greenhouse or visual tests which Dr. Erdman agrees do not constitute a scientific way of determining nitrogen fixation (R. 231-232). Likewise, Curie is the only witness who purported to know anything about the relative number of each species of bacteria in these prior garden cultures or the amount of nutrient in the base. Curie is an interested, unconvincing witness (*ante*, p. 21). His testimony was entirely from recollection of tests and processes purported to have been carried on many years prior to the date of his testimony. He failed to produce a single test report or a single written document to corroborate his recollection (R. 206-207).

Petitioner consequently is entirely unjustified in drawing any inferences from the garden mixed cultures, for it failed to prove their characteristics and properties clearly and convincingly. Mere oral testimony for this purpose is insufficient. *Eibel Co.* v. *Paper Co.*, 261 U. S. 45, 60.

From the foregoing, it is clear that there is no factual basis for petitioner's highly technical "law of nature" arguments. The facts are that Bond made an important discovery and then proceeded to apply and utilize his dis-

covery in the production of a new, different, highly useful and efficient mixed inoculant which had not been previously achieved but which Bond did achieve and of which the public now has the benefit.

We accordingly now show that under well settled principles of the patent law this amounted to patentable invention; and that no improper application of the law was made by the court below to the facts as found in this case.

I.

THE BOND PATENT IN SUIT DOES NOT MERELY DISCLOSE AND CLAIM THE DISCOVERY OF A LAW OF NATURE.

The status of a principle or a "law of nature" under the patent law was first thoroughly discussed and debated in the opinions of this Court in *LeRoy et al.* v. *Tatham et al.*, 55 U. S. 156, and *O'Reilly et al.* v. *Morse et al.*, 56 U. S. 62. As appears from the learned dissertations of the justices, and especially the vigorous dissents of Justices Nelson (55 U. S. 177 *et seq.*) and Grier (56 U. S. 129 *et seq.*), the word "principle" was employed synonymously with the idea more or less of some natural physical force, power or energy, and together these decisions established the doctrine that a principle in this sense, or a function or a result, may not be the subject of a patent. No proposition has been more frequently or positively stated by this and the lower federal courts since 1852 than that a principle or law of nature is not a patentable invention, and yet with equal frequency and positiveness this Court and the others have fully implemented the exception to the general rule, also established by *LeRoy et al.* v. *Tatham et al.*, which was to the effect that *application* of a principle or law of nature in a useful article of commerce is patentable.

In *LeRoy* v. *Tatham*, after observing that a principle cannot be patented, this Court stated (55 U. S. 175) that invention lies not in discovering natural agencies, but "in applying them to useful objects," and added that a "new property discovered in matter, when practically applied, in the construction of a useful article of commerce or manufacture is patentable." The following quotation from *Household Company* v. *Neilson*, Webster's Patent Cases, 683, was also approvingly made:

> "**A patent will be good**, though the subject of the patent consists in the discovery of a great, general, and most comprehensive principle in science or law of nature, **if that principle is by the specification applied to any special purpose so as thereby to effectuate a practical result and benefit not previously attained.**" *

Shortly afterward, in *Wintermute* v. *Redington* (C. C. Ohio, 1856), 1 Fish. Pat. Cas. 239, 30 Fed. Cas. 367, Judge Wilson succinctly and properly explained the general rule and its exception thus:

> "It is true that a patent can not be sustained for a mere principle. For instance, Sir Isaac Newton's discovery of the principle of gravitation could not be the subject of a patent. But it is equally true, that a principle may be embodied and applied, so as to afford some result of practical utility in the arts and manufactures, and that under such circumstances a prin-

* The patent of the Tathams was not invalidated in this case. The verdict of a jury in favor of the patent was set aside because of error in the charge (55 U. S. 177). The case was retried in chancery, and upon appeal from a decree upholding the patent, this Court affirmed (63 U. S. 132), saying (p. 137):

> "The 'newly-discovered property in the metal, and the practical adaptation of it, by these means, to the production of a new result, namely, the manufacture of wrought pipe out of solid lead,' was the discovery. 'There can be no patent for a principle; but for a principle so far embodied and connected with corporeal substances as to be in a condition to act and to produce effects in any trade, mystery, or manual occupation, there may be a patent.'"

ciple may be the subject of a patent. It is, however, the embodiment and the application of the principle which constitute the grant of the patent. And it has been justly said 'that the principle so embodied and applied, and the principle of such embodiment and application are essentially distinct; the former being a truth of exact science, or a law of natural science, or a rule of practice; the latter a practice founded upon such truth, law, or rule.' ''

A reaffirmation of the doctrine was made by this Court in *Sewall* v. *Jones*, 91 U. S. 171, where it was said (p. 184):

> "When a party has invented some mode of carrying into effect a law of natural science or a rule of practice, it is the application of that law or rule which constitutes the peculiar feature of the invention. He is entitled to protect himself from all other modes of making the same application."

The decision of this Court in the *Telephone* cases, 126 U. S. 1, forcibly illustrates the decided *and patentable* difference between (1) merely describing and claiming the discovery of a natural agency or law, and (2) describing and claiming either a machine, process, manufacture or composition of matter in which a natural agency is applied for a practical and useful purpose. That decision clearly reaffirms the exception to the general rule and holds that one who puts a force of nature into a certain specified condition and then uses it in that condition for a practical purpose is entitled to patent protection. Thus, it was stated by Chief Justice Waite (126 U. S. 534):

> "In the present case the claim is not for the use of a current of electricity in its natural state as it comes from the battery, **but for putting a continuous current in a closed circuit into a certain specified condition suited to the transmission of vocal and other sounds, and using it in that condition for that purpose.** So far as at present known, without this peculiar change in its condition it will not serve as a medium for the

transmission of speech, but with the change it will. Bell was the first to discover this fact, and how to put such a current in such a condition, and what he claims is its use in that condition for that purpose, just as Morse claimed his current in his condition for his purpose."

Another apt illustration of the patentable exception is found in *Cameron Septic Tank Co.* v. *Village of Saratoga Springs* (C. C. A. 2), 159 Fed. 453. In that case the patented process related to securing the separate and successive action of anaerobes and aerobes on the organic matter of the solids in a flowing current of sewage by secluding it before its passage into the aerating tanks in a septic tank where it was excluded from light, air, and agitation until by the anaerobic action generated therein all organic matter was dissolved and the entire current liquefied. Rejecting the defense that the process claims were void because they covered "a process of nature and one which cannot be covered by any one," the court said:

"* * * We, however, are satisfied that Cameron was the first one to subject a flowing current of sewage to the action of anaerobes and aerobes under conditions which secured their separate and successive action, the action of the segregated anaerobes fitting the effluent for subsequent filtration and aerobic action; and by reason of such careful segregation he was the first to secure such specified condition in the anaerobic colony that its capacity for its natural work was increased to such an extent that it became capable of disposing of practically all future inflowing sewage that entered its workshop without accumulating such a deposit of sludge as would require removal. This certainly involved 'the use of one of the agencies of nature for a practical purpose.' *Risdon Locomotive Works* v. *Medart*, 158 U. S. 77, 15 Sup. Ct. 745, 39 L. Ed. 899. **The process is one which puts a force of nature into a certain specified condition and then uses it in that condition for a practical purpose.** *Bell Tele-*

phone, 126 U. S. 1, 534, 8 Sup. Ct. 778, 31 L. Ed. 863. Within the principles enunciated in the two cases last cited, we are satisfied that Cameron's process as set forth in these five process claims is patentable."

Of the bacteria involved in the *Cameron* case, the anaerobes are micro-organisms that are killed by air; they can neither act, multiply, nor even exist in contact with free oxygen; and the aerobes are micro-organisms that die without air or oxygen. That both germs were potent in breaking up the solid parts of sewage matter was a fact long known to those skilled in the art. The significance of the *Cameron* case lies in the fact that the court upheld as patentable a new and useful process which consisted merely in carefully segregating the bacterial families and taking advantage of their respective natural capacities.

The patentable exception which is the core of the opinion of the court below was recently emphasized by this court in *Mackay Radio & Tel. Co.* v. *Radio Corp.*, 306 U. S. 86, 94, where it was said:

> "While a scientific truth, or the mathematical expression of it, is not patentable invention, a novel and useful structure created with the aid of knowledge of scientific truth may be."*

From the foregoing it is perfectly apparent that the highly technical "law of nature" defense may be sustained only when the claim is to the discovery of a natural agency or force *without more*. Also, that if the discovery has been applied or utilized in a corporeal composition, article or apparatus, for a practical purpose and to achieve a

* In that case, this Court assumed that Carter's advance was invention, even though it was achieved by the logical application of a known scientific law to a familiar type of antenna. And see also *Katz* v. *Horni Signal Mfg. Corp.* (C. C. A. 2), 145 F. (2d) 961 (Cert. denied 324 U. S. 882), where the Circuit Court of Appeals upheld a patent which made "a highly useful application of one of Faraday's discoveries."

result not previously attained, patentable invention may exist. This patentable difference has never been ignored by this or any other court. Many of the most important inventions have necessarily made use of a natural agency for a practical purpose. Again and again valuable contributions to the advancement of the arts and sciences have been made by simply putting a natural agency into a specified condition and using that agency in that condition for a practical purpose.

The court below had no quarrel with the well-established principle that a patent cannot be sustained for the discovery of a law of nature. The opinion below evidences no disposition whatever to modify or qualify either the rule or any of its clear implications. Patentability was upheld here because, as the court below found, the patentee applied and utilized a law of nature in a manner previously regarded as "dangerous practice," thereby to produce a commercial inoculant "successful, efficient and filling the need it was meant to fill." Thus the court below expressly held that the patentee "did much more than discover a law of nature. He made a new and different composition, one contributing utility and economy to the manufacture and distribution of commercial inoculants." The inoculant described and claimed by the patentee was held to be a "new patentable composition" because he had applied "scientific knowledge to things existing in nature" and had utilized them "in a desirable composite product which had not been previously achieved but which he did achieve and of which the public now has the benefit."*

It should therefore be quite obvious that since the facts

* Thus clearly the court below has found the three statutory prerequisites—novelty, utility, and invention—to exist (see *post* pp. 43-48). It is absurd to contend, as does petitioner (Br. p. 32), that the court below "would avoid the requirement of the patent statute."

are otherwise than assumed and asserted by the petitioner, the court below did not improperly apply to the actual facts a well recognized patent law principle.

Moreover, petitioner's arguments (Br. p. 21) as to the consequences of an affirmance of the court below are wholly beside the point and are, in addition, erroneous. If the Bond patent is sustained, as it should be, it will not "stop all further progress" in the inoculant art; it will instead stimulate research to find other and better ways to effect inoculation. There is no reason why manufacturers other than respondent should feel free to make mixed cultures without "fear of infringing the Bond patent." Prior to Bond they not only did not know how to do so successfully, but regarded it as *a dangerous practice.*

The Bond patent does not "monopolize an entire industry," since mixed cultures for field use constitute only a minor part of the business as compared to single cultures and are not even sold by some of the largest manufacturers (R. 237). In an attempt to magnify the "far-reaching effect" of the Bond patent, petitioner overemphasizes the use of "mixed seedings"—Bond considered this "a minor point so far as the advantages of composite cultures are concerned" (R. 98-99).

Petitioner also apparently contends (a) that Bond's product does not possess the statutory prerequisites of patentability; (b) that a patentable application of Bond's discovery of a law of nature was legally impossible because Bond did not change or modify the natural characteristics of the bacteria and did not add or take anything away from them; (c) that Bond's mixed inoculant is not classifiable subject matter under the statute and it is not a true composition of matter; and (d) that the decision in *Vitamin Technologists, Inc.* v. *Wisconsin Alumni Research Foundation* (C. C. A. 9), 146 F. (2d) 941, is an authority

requiring a holding of invalidity of the Bond patent. We now consider these untenable contentions in order:

(a) The Bond Product Is New and Useful and Possessed of the Quality of Invention.—We agree that in order to be patentable, a composition of matter must have these statutory patentability prerequisites: (1) novelty, (2) utility, and (3) the quality of inventiveness.* And we submit that the Bond mixed inoculant has all three as was found by the court below.

(1) That the Bond product is *new* within the meaning of the term "novel" found in the patent statute need not rest only on the finding of the court below that the product was "new and different," but it stands as well upon petitioner's concession of no "anticipation by reason of the prior art." The full implication of no anticipation is that prior to Bond's patent there was no mixed inoculant like or substantially like Bond's, for in order to negative "novelty" or, as it is usually expressed, "to anticipate," it is necessary that all of the elements of the invention or their equivalents be found in a single description or structure where they do substantialy the same work in substantially the same way. *Imhaeuser* v. *Buerk*, 101 U. S. 647, 660; *Bates* v. *Coe*, 98 U. S. 31; *Walker on Patents* (Deller's Ed.), Sec. 47, pp. 254, 255. Nor is "novelty" negatived by anything beneficially incapable of the function of the patent even though apparently similar thereto. Walker on Patents, *ibid.*

Petitioner indulges in confusion of thought (Br. pp. 28-32) when it concedes *arguendo* that Bond was the first to make a "commercially successful mixed inoculant" and then argues that "a thing may be new in the sense that it is placed on the market, but that does not make it new in the patentable sense," relying on *Collar Co.* v. *Van Dusen*, 23 Wall. 530, and *Boston Pencil Pointer Co.* v. *Automatic*

*R. S. § 4886, Appendix, *post* p. 75.

Pencil Sharpener Co., (C. C. A. 2), 276 Fed. 910, 912, to support the contention that Bond's product nevertheless is not new.* Those cases really dealt not with the word "novel" as used in the statute, but with the domain of invention, which is still another statutory prerequisite and which we shall consider under (3) (*post* p. 45). The true significance of the decisions relied on by the petitioner is explained in Walker on Patents, *ibid*, thus:

> "* * * The novelty required in order that an invention may be protected by a patent is that it must be new. Statements that some things are not patentable because, though new in a commercial sense, they are not new in the eye of the patent law, occur in a few reported cases. [*Boston Pencil Pointer Co.* v. *Auto. Pencil Sharpener Co.*, 276 Fed. 910, C. C. A. 2 (1921).] In every such instance, however, it would have been more accurate to say that some things are not patentable because, though new things, they are not invented things. **Such things lack patentability not because they lack newness, but because they lack invention.** [*Boston Pencil Pointer Co.* v. *Auto. Pencil Sharpener Co.*, *supra*; *Aro Equip. Corp.* v. *Herring-Wissler Co.*, 84 F. (2d) 619, C. C. A. 8 (1936).] The question belongs to the domain of invention and not to that of novelty, and it is therefore treated in the third chapter of this book."

Without question, therefore, in view of the finding of the court below that Bond's product is "new and different," fortified by petitioner's concession of no anticipation by reason of the prior art, the novelty requirement of the statute is met.

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* Petitioner argues (Br. p. 32) that as Bond did not change the noninhibitive kind of bacteria, the "newness" for which the patent was upheld is the discovery of a natural phenomenon "without regard to whether there is a 'new' structure." This is plain distortion of the court's opinion which expressly found Bond's product to be "new and different" (R. 824).

(2) That the Bond product is "useful" within the meaning of the patent statute is not seriously denied by petitioner. To possess utility, an invention must be capable of producing a result, and that result must be a good result which may be so applied in practical affairs as to prove advantageous in the ordinary pursuits of life. An invention is useful within the meaning of the statute if it is capable of performing some beneficial function claimed for it. *Smith* v. *Nichols*, 21 Wall. 112; *Seymour* v. *Osborne*, 11 Wall. 516.

The District Court was impressed with the "results" obtained by Bond, stating that his work and its value are not to be minimized, and the court below found that the Bond composite was one "contributing utility and economy to the manufacture and distribution of commercial inoculants" and was "successful, efficient and filling the need it was meant to fill." These concurrent findings are clearly supported by the evidence; they should not be disturbed. *Williams Co.* v. *Shoe Machinery Corp.*, 316 U. S. 364, 369, and cases *ante* pp. 32-33.

(3) That the Bond product resulted from the exercise of uncommon talent and thus meets the third statutory prerequisite is abundantly shown by the undisputed evidence; it is implicit in the trial judge's finding that Bond was diligent and ingenious and the discoverer of the existence of noninhibitive strains, and it was expressly found by the court below.

The history of the struggle since 1907 to provide the American farmer with a satisfactory mixed culture for field seeds leaves no room for any doubt of the inventive quality of Bond's work. It is at once absurd to say, in view of the salient historical facts, that (1) it was within the skill of the calling to produce the Bond mixed inoculant, or (2) the disclosure of the patent is less than an

outstanding contribution to the art. The classical aphorism of the late Justice Holmes in *New York Trust Company* v. *Eisner*, 256 U. S. 345, "a page of history is worth a volume of logic," requires summarily a rejection of the contention that however "skillfully Bond brought the noninhibitive bacteria together, and even though there was produced a commercial inoculant that was more efficient," it is still "the product of skill, not of invention."*

Bond taught those working in the art not only that a satisfactory mixed culture for field legume seeds could be made, but also how to make it. Specifically he *discovered* and published to the world the existence of mutually noninhibitive strains of root nodule bacteria which can be selected and isolated by standard and routine tests. With this startling discovery as his genesis, Bond taught the art that to produce an efficient, dependable mixed culture, the selected noninhibitive strains or species of bacteria should be grown separately and then incorporated in large numbers of substantially the same order of magnitude in a powder base low in, or substantially free from, nutrient.

Without question Bond took the *last step* which solved the problem of thirty years' standing of how to prepare a satisfactory commercial mixed culture for leguminous plants of the field type. *Cf. The Barbed Wire Patent*, 143 U. S. 275, 283; *Consolidated Valve Co.* v. *Crosby Valve Co.*, 113 U. S. 157, 179. But not only did Bond take the last step which turned failure into success, but also he disabused the art of a misconception which was the very foundation of the failure. As was said by Judge Learned Hand in

* The facts in *Altoona Publix Theatres, Inc.* v. *American Tri-Ergon Corp.*, 294 U. S. 477, from which petitioner borrowed this quotation (Br. p. 35), are entirely different from those present here. The use of a flywheel, which was the gist of the invention, was an obvious prior art expedient within the skill of the calling, and no new result was obtained.

E. I. Du Pont de Nemours & Co. v. *Glidden* (C. C. A. 2), 67 F. (2d) 392, 397:

> "* * * If Flaherty did no more than disabuse the art of a misconception, it is evidence of originality; most of us persist in what we are accustomed to believe. Though all he did was to carry forward the existing knowledge that lower viscosity would result in greater coverage, other competent persons had tried to use that knowledge; the stimulus to success was great, and the art had been either strangely inert, if the combination was obvious, or else obsessed with a belief that low viscosity was impracticable. The result was a new and unexpected product, recognized as such, and used to much advantage. We know of no rigid doctrine, divorced from those practical considerations which rightly or wrongly are basic in the patent law, that forbids to such an advance the name of invention."

Of course, now that the last step has been taken, the hindsight of those who failed to solve the problem must be cautiously received and carefully examined. Present day knowledge must not be read into prior art patents which taught the art nothing and which have "emerged from oblivion solely to meet the exigencies of this litigation" or into the unused and unusable inoculants described in the prior publications or into the garden variety cultures as to the characteristics of which there is no clear and convincing proof. Neither should the seeming simplicity of Bond's work adversely affect the question whether inventiveness was exercised. See *Expanded Metal Co.* v. *Bradford*, 214 U. S. 366, 381; *Diamond Rubber Co.* v. *Consolidated Tire Co.*, 220 U. S. 428, 435; *Goodyear Co.* v. *Ray-O-Vac Co.*, 321 U. S. 275. In the *Goodyear* case, Mr. Justice Roberts said:

> "Viewed after the event, the means Anthony adopted seem simple and such as should have been obvious to those who worked in the field, **but this is not enough to negative invention.**"

The trial court found that Bond had been diligent and ingenious and the court below thought that he "made an inventive step forward in the art of production and commercial distribution of composite inoculants" and that the teaching in his patent of the production of a "composite inoculant, successful, efficient, and filling the need it was meant to fill" was an "inventive conception." There is abundant factual support in the evidence for these findings. They should not be overturned unless clearly erroneous and except for cogent reasons. *Williams Co.* v. *Shoe Machinery Co.*, 316 U. S. 364, 367.*

(b) The Patentable Application of a Discovery of a Law of Nature Is Not Dependent Upon Modification or Change of the Natural Force or Agency; nor Is It Dependent on Use in a Manner or for a Function That Is Not Accomplished in Nature.—The underlying basis of petitioner's discussion under Point I (Br. pp. 19-27) is a fundamental fallacy adopted and pursued by petitioner without justification or warrant either under the patent statutes or the precedents, *i.e.*, that patentable invention was not achieved by Bond because he did not change or modify the bacterial life or use it for a purpose or function foreign to the natural function or add to or take something away from the bacteria themselves. The fallacy is repeated with variations in the discussions under Points II and III, where it is argued (Br. pp. 28-35) that contributions existing in nature cannot be the basis of patentable invention.

* Such cases as *Hotchkiss* v. *Greenwood*, 11 How. 248, 266; *Rubber Tip Co.* v. *Howard*, 20 Wall. 498, 507; *Smith* v. *Nichols*, 21 Wall. 112, 119; *Toledo Pressed Steel Co.* v. *Standard Parts, Inc.*, 307 U. S. 350, 356, and *Old Town Ribbon Co.* v. *Columbia Co.* (C. C. A. 2), 159 F. (2d) 379, 382, involved different factual considerations. In order to impair these decisions even superficial resemblance, petitioner's distorted view of the evidence and facts which was rejected by the court below must be accepted.

There is absolutely no basis for petitioner's restrictive and unreasonable construction of our patent laws. Certainly the decisions relied on by petitioner do not support it, as we shall presently show. The true rule is that evident from our discussion (*ante*, pp. 36-41) of the difference between patentable invention and merely describing and attempting to patent the discovery of a principle or law of nature, as, for example, the doctrine of the *Mackay* case, that a novel and useful structure created with the aid of or utilizing a natural agency or a scientific truth is patentable. It is not a necessary element of patentable invention that the natural agency or force be used in a manner or for a function that is not accomplished in nature. As man is incapable of changing or modifying the immutable laws of nature, no court has ever required that he do so to qualify as an inventor. All that is necessary is that the natural agency or force be placed in a specified condition and used in that condition for a practical purpose. *The Telephone Cases*, 126 U. S. 1, 534; *Cameron Septic Tank Co.* v. *Village of Saratoga Springs* (C. C. A. 2), 159 Fed. 453.

The phrases "application of the principle" and "application of a discovery of a law of nature" as used in the decisions upholding patentability (*ante*, pp. 37-39) denote only the embodiment of the principle or natural agency or force in some physical structure, composition or art; in other words, these phrases signify the reduction to practice of the principle or agency or force.

According to Robinson on Patents, Vol. 1, Sec. 140, p. 200, until a principle is reduced to practice "it is not a complete invention, nor does it stand on any higher ground of legal merit than the discovery of an existing natural power. It must become 'a principle, put in practice and applied,' a 'practice founded on principle,' before it passes from the

shadowy regions of mere intellectual apprehension into the domain of the industrial arts." The same learned writer states (Sec. 143, p. 203) that when the courts say that "one who has discovered and *applied* a principle is entitled to all methods of applying it," which is the rule deducible from *Househill Co.* v. *Neilson*:

> "they speak of an idea of means, capable of being applied or reduced to practice in different instruments or operations, each of which is the tangible embodiment of the same idea, and all of which are only formal variations of the same substantial means."

The critical difference between patenting a discovery and patenting an application of the discovery is that in the first case, an attempt is made to monopolize a principle or an abstraction or a result, whereas in the second case the monopoly exists only in respect of a specific embodiment or connection of the principle with corporeal substances in a condition to act and produce effects in the industrial arts. Novelty, utility, and invention being met (*ante*, pp. 43-48), it is not otherwise necessary that Bond's application or embodiment of a natural agency be along lines or for purposes which require the agency to function otherwise than naturally.

If petitioner's conception of what constitutes patentable application of a principle or natural agency is correct, and of course it is not, then literally thousands of the important patents granted under our patent system and utilizing natural forces or agencies for the very same functions accomplished in nature, should never have been granted; indeed, very few of the contributions made to the advancement of the arts and sciences since the founding of our republic could have qualified for patenting. Petitioner's view of the law is illogical and absurd; it is not supported by any decision.

Thus *Morton* v. *New York Eye Infirmary*, 17 Fed. Case 881 (S. D. N. Y. 1862) (Pet. Br. p. 20), serves only to crystallize the difference, already adverted to by us (and admitted in that case by the court), between a claim to the discovery of a new principle and a claim to the use of a principle in a particular medium or mechanical contrivance by which it acts on the material world. True the patent there was held invalid, but the broad and sweeping doctrine claimed for the case is not justified. The patent in the *Morton* case attempted to cover *all surgical operations* in which ether was used as an anesthetic—not a physical or other corporeal embodiment or application of the discovery.* The result reached in that case is not dispositive here because Bond manifestly has not attempted to patent the process of fixing nitrogen in leguminous plants. The Bond claims relate to a specific composite inoculant in which advantage is taken of a discovery. Nothing is said in the *Morton* case, either expressly or by implication, to the effect that a modification or change of the natural agency must be made.

Nor does *Le Roy et al.* v. *Tatham et al.*, *supra*, (Pet. Br. pp. 22-24), forbid the grant of a patent for a new and useful composition of matter utilizing a natural agency for a practical purpose. As we have observed, this case expressly recognized the principle of law on which the court below relied. This decision and the *Telephone* cases (Pet. Br. p. 24) may be searched in vain for any ground or other support for petitioner's unreasonable conception of what

* Morton and Jackson admitted in their patent that, prior to their invention, fumes of sulfuric acid ether (di-ethyl ether, $CH_3CH_2OCH_2CH_3$) had stupefied persons and animals who breathed the fumes, their alleged invention being solely the discovery that while in this condition persons could be operated on without pain and without movement due to muscular contraction. Thus, the patentees had neither discovered ether itself nor the effects of ether.

constitutes a patentable application of a principle or discovery.

Equally unavailing to petitioner is *O'Reilly et al.* v. *Morse et al.*, 56 U. S. 62 (Pet. Br. p. 23). The doctrine of that decision is applicable only in the case of claims covering a principle, function, or result *without more*. The eighth claim of Morse, instead of being directed to a specific embodiment and application of the discovery, as was true of the first seven claims which this court upheld, was directed to the natural force or principle itself irrespective of the "specific machinery or parts of machinery described" in the specification and preceding claims. It was not held in this case, as intimated by petitioner, that in reducing a natural force to practice, a change or modification of the force must be made.

Smith v. *Nichols*, 21 Wall. 112 (Pet. Br. p. 23), also does not lend any support to petitioner's interpretation. That case had nothing whatever to do with a law of nature situation. The decision stands only for the well recognized proposition that a mere change in degree is not patentable invention.

De Forest Radio Co. v. *General Electric Co.*, 283 U. S. 664 (Pet. Br. pp. 24-25 and 35) does not even superficially resemble the case at bar. On close scrutiny, the decision does not go as far as the brief quotation made by petitioner suggests. Langmuir appears to have utilized the current knowledge of the art in 1913 to claim as his invention the exhaustion of the occluded gases in a vacuum tube by which he reduced or eliminated the phenomenon of ionization during use. It was known that the phenomenon of ionization made for unsteadiness and demanded nice adjustment for each tube in a radio circuit. Thus, reduction so far as possible of the phenomenon, and causing the electrons to pass *in vacuo* from the filament to the plate, was a desirable

and well-known condition, having been declared in scientific periodicals by Lillienfeld. Langmuir's disclosure was merely that of a completely exhausted tube; at the time of his application there was no demand for such a tube and the art did not yet need it. Thus Langmuir merely put in practical form, before needed, the scientific discoveries of others. Read in this light, the quotation from this court's opinion is entirely inapposite here.

In further pursuit of petitioner's basic fallacy, *i.e.*, that it is essential to validity that Bond should have changed or modified his bacteria, it cites and relies on *Union Carbide Co.* v. *American Carbide Co.* (C. C. A. 2), 181 Fed. 104, and *J. E. Baker Co.* v. *Kennedy Refractories Co.* (C. C. A. 3), 253 Fed. 739. A close examination of these opinions, which were particularly relied on by the court below, will show that the distinction which petitioner makes is quite irrelevant. For example, the significance of the *Union Carbide* decision resides in the similar contentions of the infringer there and the infringer here, *i.e.*, that the patent is not for a new product, but for a new form of an old product, having the same composition, properties, and uses of the old. The amorphous calcium carbide in that case may be considered *arguendo* the equivalent in this case of the mixtures of natural bacterial life found in nature; the crystalline form there in the same position as the mixed inoculant of Bond here. Patentability there was upheld because it was founded (181 Fed. 106-107):

> "upon superior efficiency; upon superior durability, including the ability to retain a permanent form when exposed to the atmosphere; upon a lesser tendency to breakage and loss; upon purity, and, in connection with other things, upon comparative cheapness."

Similar attributes may be ascribed to the Bond product as compared to natural bacterial life, and the conclusion

of the court in the *Union Carbide* case aptly expresses the clear right of the Bond product to patentability, thus (pp. 107-108):

> "For these reasons, it is held that the product possesses the requisite patentable novelty. And we must regard this conclusion as not only well founded in law, but as most just. **To hold an important discovery which has given to the world a commercially new product—a product the high utility of which must be conceded—not entitled to protection for want of novelty, would, as it seems to us, be applying the patent statute to defeat its fundamental purposes.**"

General Electric Co. v. *De Forest Radio Co.*, (C. C. A. 3), 28 F. (2d) 641, clearly is not in point, for there the broad claim of the patent read;

> "26. Substantially pure tungsten having ductility and high tensile strength."

The remarks of the court relied on by petitioner were addressed to this palpable effort to claim a product of nature and no more. It is a far cry from Coolidge's claim to the claims here; Bond does not claim only alpha strains of bacteria, but on the contrary he claims a corporeal embodiment (a mixed inoculant employing alpha strains) capable of practical use and which does not exist in nature, as does pure tungsten.

Universal Winding Co. v. *Foster Mach. Co.* (D. C. Mass.), 16 F. Supp. 671, is also inapposite. No one quarrels with the abstract rule quoted by petitioner. Significantly, however, the quotation does not support petitioner's contention that changes in natural forces are required. Quite the opposite, it is clearly implied that all that is required is that the patentee merely bring the law of nature *into operation* by novel means. Bond's new and different product clearly satisfies the rule of this case.

All that the patentee had done, in *Novocol Chem. Co.* v. *Powers & Anderson Dental Co.* (C. C. A. 4), 128 F. (2d) 904, 907, was to satisfy himself that the cause of discoloration of epinephrin was oxidation and not contact with the rubber or glass of the containers. This scientific fact was well known, and prior workers had attempted airtight cartridges. It was accordingly held that no "great originality of thought" was involved in the conclusion that "some air was reaching the solution" in the prior devices. The case is not in point because there the remedy was obvious and of long practice (128 F. (2d) 907). Here Bond's solution was not obvious; neither was it one of long practice (*ante*, pp. 43-48). The *Novocol* case does not indicate that a change or modification of the physical fact is required; on the contrary, petitioner's quotation reveals that patentability is achieved when the discovery is utilized in an invented thing.

The foregoing analysis of the decisions relied on by petitioner clearly shows that the contention that the Bond patent is invalid because he did "not make any change in or modify the bacteria used in his product" must fail.

(c) The Inoculant Disclosed in the Bond Patent Is Properly Classifiable as a Composition of Matter.—The words "composition of matter" found in the patent statute R. S. 4886, 35 U. S. C. Sec. 31, presuppose only a composite material consisting of a number of elements. The phrase "covers all compositions of two or more substances. It includes all composite articles, whether they be results of chemical union, or of mechanical mixture." Walker on Patents (Deller's Ed.) Sec. 14, p. 55. See also *Keasbey & Mattison Co.* v. *Philip Carey Mfg. Co.* (C. C. N. Y.), 139 Fed. 571, 573; *Union Carbide Co.* v. *American Carbide Co.* (C. C. A. 2), 181 Fed. 104, 106-107; *J. E. Baker Co.* v. *Kennedy Refractories Co.* (C. C. A. 3), 253 Fed.

739; *National Battery Co.* v. *Richardson Co.* (C. C. A. 6), 63 F. (2d) 289, 292; *Kuehmsted* v. *Farbenfabriken of Elberfeld Co.* (C. C. A. 7), 179 Fed. 701, 705; *Parke-Davis & Co.* v. *H. K. Mulford Co.* (C. C. N. Y.), 189 Fed. 95, 103.

In *National Battery Co.* v. *Richardson Co.*, Judge Hickenlooper said (63 F. (2d) 292):

> "* * * The fact that all the elements of patentee's composition had formerly been used separately to perform the same or similar functions, or had been used in various other but never the same combinations, will not defeat the patent. *Bates* v. *Coe*, 98 U. S. 31, 48, 25 L. Ed. 68; *Emery* v. *George H. Bowman Co*, 11 F. (2d) 525 (C. C. A. 6). The question then is whether the new combination would be obvious to one skilled in the art to whom the problem was submitted for solution. *Webster Loom Co.* v. *Higgins*, 105 U. S. 580, 591, 26 L. Ed. 1177."

A "composition of matter" is thus a product involving inventive conception and formed by the intermixture of two or more substances or ingredients. Each of the ingredients is, of course, a means to an end, but the true attributes of a "composition of matter" result either from the *positive* or *negative* (as the case may be) relationship or interaction of the ingredients in producing a new and characteristic use or result. Thus the essence of a true composition of matter resides in the intermixture and relationship of the individual ingredients in a whole complex utilized as a unit, each ingredient being necessary to the common result and "yielding something to the useful arts." (179 Fed. 705.)

The subject matter of the Bond claims easily meets the requirements of a "composition of matter." As disclosed, as claimed, and as used, the Bond inoculant is much more than natural bacterial life *per se*. It is a combination of selected bacterial strains placed together in a specified con-

dition, *i. e.*, large numbers, in a powder base of low nutrient; thereby it became "for every practical purpose a new thing." (189 Fed. 103.)

It is true that, as specified in the Bond patent claims, the different bacterial species "do not affect one another in their ability to fix nitrogen," and that when each species of the mixed inoculant works it does so independently of the others. But it is mere play on words to say that this is aggregation and not a true composition of matter, or that each element has not lost its identity. A brief consideration of the salient facts compels the conclusion, reached by the court below, that Bond's product has the essential attributes of a "composition of matter."

The most important desired end in the seed inoculant art was the provision of an inoculant containing two or more different species of bacteria which are not injuriously affected by each other during packaging, storage, and distribution. Without the attainment of this important end the optimum inoculation of the several types of seeds for which the mixture is intended cannot be secured.

The evidence leaves no doubt that the problem which confronted the seed inoculant manufacturers respecting mixed cultures for field seeds was one of storage and distribution. The jobbers and dealers had long required a convenient form of handling and distributing field seed inoculants other than in separate cartons (R. 140-141). It was to the solution of this problem that Mr. Bond turned, and it was his discovery of the existence of noninhibitive strains of bacteria which paved the way to the preparation of a mixed culture which satisfied a long-felt want. Thus the Bond invention resided in assuring a *negative* relationship as between the different species as distinguished from a *positive* interaction. Where the inventive step lies in the provision of a *negative* rather than a *positive* condi-

tion, and where, indeed, this was the desideratum itself, it is both illogical and absurd to contend, as does petitioner, that a true composition of matter has not been achieved merely because of the absence of positive interaction or because the elements do not lose their identity.

Even though the individual bacterial species in the Bond inoculant do not interact in the mixture, they cooperate in that they are capable of living together without harmful interaction and can thus fulfill the purpose for which the mixture was intended; they also cooperate in that they have individual qualities which permit them to be present in a unit intended for a single purpose; and they also cooperate with each other in that although each performs its particular function only, they jointly contribute to the provision of a mixture heretofore unavailable which may be safely packaged, stored, and distributed.

The principal object of the Bond invention is to provide an inoculant or mixed culture containing two or more species of bacteria which are *not* injuriously affected by each other but which function with the same efficiency as if the separate species of bacteria were contained in separate inoculants. *This lack of inhibition or of adverse effect on each other by different species of bacteria in a mixed inoculant is new in the art.* Such an inoculant, a true composition of matter, was made possible by the step forward made by Bond. The court below was convinced that Bond's inoculant was a true composition of matter when, after reviewing the evidence, it said (R. 827):

> "Thus he taught how to make a composite inoculant, successful, efficient and filling the need it was meant to fill. This is not so-called 'aggregation.' It is inventive conception."

It is to be noted that in the *Sharpless case*, 287 Fed. 655, from which petitioner quotes (Br. p. 28), the court said (p. 658):

> "* * * It is to be observed Congress provided for invention in respect 'of composition of matter' as one of the four classes of invention. There is no restriction as to the nature of the composition which may be patented. **The only limitation is they must be new, useful, and the result of invention.**"

Since, as we have shown (*ante* pp. 43-48), the Bond product meets the three requirements of the statute (the only limitation), it is patentable as a composition of matter.

The language from the *Sharpless* case, on which petitioner relies, is merely exemplary of one way in which a patentable composition of matter "may well result or be formed" for it clearly was not intended as a "restriction as to the nature of the composition which may be patented." In any event the "different or additional" property which the Bond inoculant possesses is its ability (not possessed by any of the individual ingredients) to fix nitrogen in leguminous plants of more than one cross-inoculation group with the same efficiency as single inoculants utilizing the same strains.

American Fruit Growers, Inc. v. *Brogdex*, 283 U. S. 1 (Pet. Br. p. 27), decides only the question of what constitutes a "manufacture" as that word is employed in the patent statute. The patent disclosed a method of preparing fresh citrus fruit for market by applying borax to the skin or rind, and sought to claim as a new article of manufacture:

> "26. Fresh citrus fruit of which the rind or skin carries borax in amount that is very small but sufficient to render the fruit resistant to blue mold decay."

It was held by this Court that the addition of borax to an orange did not produce any change in its name, appear-

ance, or general character, and hence the claim did not relate to a "manufacture" as that term had been defined in previous decisions of this Court.

"Manufacture" and "composition of matter" are separate and distinct statutory classifications. A precedent dealing with one of these classifications is not in our submission controlling as to the other.

It is of no minor significance or weight that the Patent Office in issuing the Bond patent in suit has created a presumption of classifiable statutory subject matter. Thus *prima facie*, by virtue of the very grant of Bond's patent, the Bond mixed inoculant is a true "composition of matter." This *prima facie* is reinforced abundantly by the presence in this record of numerous patents dating as early as 1907, issued for similar subject matter by those in charge of the administration of our patent laws (R. 780-808). A long-standing administrative interpretation of the patent statute recognizing employment of natural bacterial life as statutory subject matter should not now be lightly overturned on the basis of the strained and fallacious arguments of petitioner.

It is a well-settled principle of federal statutory interpretation that the construction given a statute by those charged with its execution has weight with the courts and will not be overruled without cogent reasons. *United States* v. *Moore*, 95 U. S. 760. The principle has been applied in ascertaining the meaning of "manufacture" as used in the patent statute, *Riter-Conley Mfg. Co.* v. *Aiken* (C. C. A. 3), 203 Fed. 699, 702, (Cert. Denied 229 U. S. 617) and for the purpose of construing the Copyright Act (15 U. S. C. § 12), *Washingtonian Publishing Co.* v. *Pearson*, 306 U. S. 30.

(d) The Vitamin Technologists Case Is Not Parallel to the Facts in This Case.—The claimed process involved

in the *Vitamin Technologist* case (146 F. (2d) 941) was that of preparing food materials and exposing them to irradiation by ultraviolet rays for a period sufficient to effect antirachitic activation, which was held invalid by the court by virtue of anticipation.

The undisputed evidence in that case showed that man had always employed this process in the sun-drying of hays and coconut meat. It was also shown that prior to Steenbock's application for patent, Goldblatt and Soames had applied ultraviolet rays to living rats and had thus produced in their livers an antirachitic factor whereby the livers, when fed to rachitic rats, aided or cured their rickets. Likewise Hume and Smith had, prior to Steenbock, used an ultraviolet lamp to irradiate sawdust, producing in it vitamin D which rachitic rats ate and were cured. Steenbock was familiar with the work of the earlier scientists, and therefore merely determined the scientific principles involved. The court properly held that the determination of the reason of a prior used process is not patentable invention, the process itself being anticipated.

A critical difference between the facts in the case at bar and those in the *Vitamin Technologists* case is that Bond, unlike Steenbock, did not merely determine the reasons for the successful operation of prior mixed inoculants, there being no such inoculants either described or used. Instead, Bond discovered the existence in nature, contrary to universal belief, of noninhibitive strains of bacteria; and aided by this scientific knowledge, Bond selected and combined noninhibitive strains in a composite inoculant which had never before been known.

Whereas Steenbock's process was held to be anticipated, petitioner has conceded no "anticipation by reason of prior art" of Bond's product, and therefore its contentions that the unsuccessful prior mixed inoculants would if used today

infringe the Bond patent because they may have contained both inhibitive and noninhibitive strains of bacteria are unavailing. Petitioner has wholly failed to prove that the prior mixed inoculants contained noninhibitive strains (*ante*, pp. 33-35) and hence cannot be heard to say that Bond merely recognized a scientific truth employed in the prior inoculants.

The discussion in Judge Healy's concurring* opinion concerning the patentability of a discovery of a law of nature has no persuasive force, because in this respect he was dissenting from the majority opinion of the court, which said (146 F. (2d) 949):

> "Appellant also argues that the patents seek a monopoly of the ultra violet rays of the sun or lamp, a natural force, and are hence invalid under our decision in *Wall* v. *Leck*, 9 Cir., 66 F. 552. We do not agree.
>
> * * * * *
>
> "The ultra violet rays of the mercury vapor lamp are natural forces, like such rays in the sun's spectrum, in the sense there are no forces but those of nature of which man is a part. But their use when created by a lamp to activate the antirachitic principle in lipoids processed by exposure to the lamp rays **if not anticipated and properly claimed**, is as patentable a process as the use for motor power of electricity created by a dynamo, though the electricity so created be identical with that of the lightning of an electric storm."

The *Vitamin Technologists* case is thus revealed as another authority recognizing the exception to the law of nature rule (*ante*, pp. 36-42) and confirming that an application of a natural force or scientific truth in a novel and useful structure is patentable invention. Invalidity there was occasioned by anticipation. Bond's product is not anticipated.

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* The opinion is designated as "concurring", for the reason that Judge Healy agreed with the result of the main opinion and specifically with the finding of anticipation.

II.

PATENT CLAIMS THAT DEFINE A NEW BACTERIOLOGICAL PRODUCT DISTINCTLY AND EXACTLY IN THE ONLY LANGUAGE AVAILABLE TO THE ART, FULLY MEET THE REQUIREMENTS OF THE STATUTE AND ARE NOT INVALID AS BEING FUNCTIONAL.

The patent statute (Appendix, *post*, p. 75) requires only that an applicant "particularly point out and distinctly claim the part, improvement or combination which he claims as his invention." The vice of the claims which this Court has struck down as not in compliance with this provision of the statute lies not in the mere use of functional language, but rather in the failure of the claims to depict the invention with the particularity and distinctness required by the statute, and in the consequent extension of the patent monopoly beyond the real invention or discovery.

In *Holland Furniture Company* v. *Perkins Glue Company*, 277 U. S. 245, the real invention "was that by the use of a particular kind of starch as an ingredient a new composition of matter was made." The claims in suit, however, did not describe the particular ingredient, but instead called for a glue having a starch base and capable of performing all the functions of animal glue. This, it was said, was an attempt to cover all starch glues having these properties, thereby to exclude others from all types of starch and extend the patent "beyond the discovery." The vice of the claims lay in their effect on the art, not in the mere fact that *functional* language was employed. Obviously non-functional language was available to the patentee. Thus this Court said (p. 255):

> "* * * The glue made of this ingredient within the specified range was a new product. * * * As such it was entitled to the protection of a patent but as thus described and limited petitioner's product does not infringe."

Again, in *General Electric Co.* v. *Wabash Appliance Corporation*, 304 U. S. 364, the invention consisted of a filament for electric lamps composed of tungsten made up of grains of a particular size and shape, but the claim instead of specifying the structure of the grains, defined them as being

> "of such size and contour as to prevent substantial sagging and offsetting."

This Court, referring to the *Holland* case, held (p. 371) that the claim, which merely described the function of the grains, was "insufficient" as a description of the invention, and that the vice of the "conveniently functional language" was that it "would extend the monopoly beyond the invention." As in the *Holland* case, other language might have been employed to define the actual invention, and this Court recognized not only that difficulties of language might be encountered, but also that functional language *per se* is not proscribed by the statute, saying (pp. 371, 372):

> "A limited use of terms of effect or result, which accurately define the essential qualities of a product to one skilled in the art, may in some instances be permissible and even desirable, * * *.
>
> * * * * * *
>
> "* * * The difficulty of making adequate description may have some bearing on the sufficiency of the description attempted, * * *."

The most recent pronouncement of this Court (*Halliburton Oil Well Cementing Co.* v. *Walker*, 329 U. S. 1) merely extends the doctrine of the *Holland* and *General Electric* cases to machine or combination claims. Again the vice of the claims was held to be that they were too broad and if sustained would extend the monopoly beyond the real invention of the patentee. The language, so aptly used by the Court to distinguish between a proper (physical character-

istics or arrangement) and an improper (what it will do) description of the "tuned acoustical pipe" which constituted the crucial element of the claims there involved, becomes, in the light of the facts of that case, entirely inapposite here.

In the *Halliburton* case, Walker's improvement consisted of adding to the prior Lehr and Wyatt machine a well known mechanical acoustical resonator which did not change or modify the fundamental measuring and recording functions, but merely enabled a more accurate indication to be recorded on a graph by means of more prominent, easier to count, waves. Claims of the patent not in suit, such as claims 2 and 3, described (or specified), Walker's tuned acoustical pipe as an integral part of the whole device showing its structure, its working arrangement in the combination, and the manner of its connection with the other parts. Halliburton, who employed an electrical filter in lieu of Walker's mechanical acoustical resonator, did not infringe and was not charged with infringement of these claims. On the other hand, not one of the claims in suit which Halliburton was found to infringe, *e.g.*, claims 1, 13, 14, 15, and 17, even suggested (a) the "physical structure of the acoustical resonator," or (b) the "physical relation" of Walker's addition to Lehr and Wyatt, or (c) the manner in which it operated together with the old machine to achieve the new function. For example, typical claim 1 defined the "resonator and its relation to the rest of the apparatus" as "means associated with said pressure responsive device for tuning said receiving means to the frequency of echoes from the tubing collars of said tubing sections to clearly distinguish the echoes from said couplings from each other."

Without question, therefore, not only did the claims in suit fail "adequately to depict the structure, mode, and

operation of the parts in combination," but also the most crucial element of the combination was claimed in terms of the function or result of the resonator. It is also plain from the very contention of Walker that the claims were intended to bar anyone from using in an oil well "any device heretofore or hereafter invented which combined with the Lehr and Wyatt machine performs the function of clearly and distinctly catching and recording echoes from tubing joints with regularity" (329 U. S. 12).

Thus the situation before this Court in the *Halliburton* case was this: Walker's resonator was capable of precise physical description; some of the patent claims contained such description; others, those in suit, did not employ such description, but on the contrary defined only the function or result of the resonator; the defendant Halliburton was not using Walker's actual invention, did not infringe those claims which employed the physical descriptions, but did, by a device (an electric filter) not disclosed or suggested by Walker, achieve the latter's function or result.

In the case at bar, the bacterial life employed in Bond's product is incapable of mere physical description; in fact, it is customarily described and classified by its physiological characteristics, *i.e.*, what it will do. When dealing with legume bacteriology, scientists do not use as their tools definitions or language connoting physical characteristics. For example, it is conceded that the clover bacteria, *Rhizobium trifolii*, are distinguishable from the alfalfa bacteria, *Rhizobium meliloti*, not by their physical characteristics, but by the *effect that they have* on clover plants and alfalfa plants. So here, noninhibitive strains ("alpha" strains) do not differ from inhibitive strains in physical characteristics (Bond pat. R. 777, col. 1, lines 38-44). Pointing out that noninhibitive strains are not "readily iden-

tifiable in nature, as separate species," the court below said (R. 826):

> "There is no weight and measure method by which he (the scientist) may determine the quality or quantity of bacteria * * *"

In each of the Bond product claims there has been no attempt (as distinguished from Walker's claims) to define the noninhibitive strains employed in the mixed inoculant in terms other than those which a bacteriologist commonly uses; each claim specifies the bacteria physiologically, *i.e.*, what it will do.* Here petitioner (unlike Halliburton) used as its mixed inoculant an intermixture of the precise character described by Bond in his specification and defined in the claims in suit. The court below expressly found that petitioner uses noninhibitive strains of the type described and claimed by Bond, and this finding is not challenged. Here (unlike the *Halliburton* case) there is no purpose, express or implied, to bar anyone from achieving Bond's result save insofar as use of Bond's actual invention is concerned. Others are free to prepare and sell mixed inoculants; others are free to achieve artificial inoculation of legume plants; we insist here only that such others keep clear of Bond's reservation as described and claimed in his patent. Walker's difficulty was that he was claiming too much and was endeavoring to extend his monopoly beyond his actual invention. Bond is in no such difficult or unreasonable position.

There is nothing in the *Halliburton* case or in the statute

* Bond claim 2 (R. 779), the only product claim not in suit, was not asserted against petitioner only because petitioner does not sell a "3 in 1" mixed inoculant. There was no intention, therefore, to keep this claim out of suit for the reason which had compelled Walker to omit certain of his claims from suit. Similarly, Bond method claims 9, 10, and 11 were not asserted by respondent because petitioner merely sells but does not make the infringing product.

itself that militates against the use of physiological characteristics to distinctly define the claimed invention, nor has it ever been held that a statement of the physiological characteristics is objectionable as "functional."

In the case of *Guaranty Trust Co. of New York* v. *Union Solvents Corporation*, 54 F. (2d) 400 (D. Del.) (Aff'd. *per curiam* 61 F. (2d) 1041, C. C. A. 3, Cert. Den. 288 U. S. 614), the Weisman patent 1,315,585, which was held valid and infringed, identified and described the bacteria which constituted the crucial element of the invention solely by their physiological characteristics. Claim 3, for example, identified the bacteria as (p. 403):

> "the herein described bacteria which are capable unaided of converting sterile fermentable cereals substantially into acetone and butyl alcohol."

The court pointed out that the "herein described bacteria" had reference to the specification, and it clearly appears from the opinion (p. 404) that the specification identified and described the bacteria *solely by their physiological characteristics.*

The claims of the Bond patent define the product with precise exactness in language that cannot be misunderstood* and are not subject to the vice of the claims considered by this Court in the *Holland*, the *General Electric*, and the *Halliburton* cases, *supra*. Moreover, the claims do not exclude others from the use of all mixed cultures however made. The way is left open for experimentation and research to improve the base or carrier or to otherwise change the environment of the bacteria so as to permit the use of inhibitive strains. Furthermore, the public is en-

* None of petitioner's or respondent's experts had any criticism of the language employed in the Bond specification and claims. They had all read and they all understood the nature of the Bond invention, and the designation of the "alpha" strains by their physiological characteristics gave rise to no objections or doubts.

tirely free to use noninhibitive strains in single cultures just as they were before Bond's invention.

The case of *Standard Brands, Inc.* v. *National Grain Yeast Corporation*, 308 U. S. 34, does not stand for the rule stated by petitioner (Br. p. 38). The '105 patent there in suit was held invalid not because of the form of the claims, but because (p. 38):

> "The disclosure of the patent is * * * too vague and indefinite to constitute invention."

As to the disclosure of the Bond patent and the necessity of testing for non-inhibitive strains, the court below said (R. 826):

> "* * * True, routine experiments are to be employed, but these tests are conventional and well known to bacteriologists. The mere provision that the compound shall be made of strains or species of bacteria selected by familiar methods leaves nothing indefinite in the description. * * * Where those methods are old and well known to the art, no difficulty is encountered in a description for a patent composite which provides for their utilization or employment. In other words, Bond's tests were manifest to readers skilled in the art. No one so skilled would have any difficulty in determining what he should do when his attention was directed to the necessity of making them. *Eibel Process Co.* v. *Minnesota & Ontario Paper Co.*, 261 U. S. 45, 63. As the Supreme Court has indicated, we think that intelligent bacteriologists, setting out properly to gather together the enumerated ingredients which are prescribed for the composite article, reading the description, could hardly go astray. *Seabury* v. *Am Ende*, 152 U. S. 561. The requirement that preliminary tests must be made does not invalidate a specific method when their character and limitations are well known to the art. *Minerals Separation, Ltd.* v. *Hyde*, 242 U. S. 261; *A. B. Dick Co.* v. *Barnett*, 288 Fed. 799, 801 (CCA 2)."

Petitioner's discussion of patent claims involving a "Mental Operation" on the basis of the decision of this Court in the *Halliburton* case (Br. pp. 39-41) is wholly fallacious. The claims of the Walker patent there in suit were machine or combination, not "process", claims, and the claims here in suit are product, not "process", claims as petitioner states.

The suggestion that this Court's opinion in the *Halliburton* case dealt with an attempt "to monopolize functionally indefinite mental processes" is obviously unwarranted. The note in the George Washington Law Review, Vol. 13, No. 4, pages 498-9 cited by petitioner (Br. p. 41) does not refer to this Court's decision; on the contrary, the discussion is concerned with that part of the opinion of the Circuit Court of Appeals for the Ninth Circuit (146 F. (2d) 817) which invalidated Walker patents No. 2,209-944 and Re. No. 21,383, both of which were for *methods*, held to be "directed to mental steps", and neither of which came before this Court.

Obviously, the product claims of the Bond patent are not directed to "a method of computation" as was true of the patent in the *Don Lee* case (Pet. Br. p. 40) and of the two Walker patents invalidated in 146 F. (2d) 817.

The short answer to petitioner's discussion of "Therapeutic Methods" (Br. pp. 41-42) is that the Bond mixed inoculant is not *therapeutic*, nor is it a *method*. If it were true that the Brinkerhoff decision has established a tradition in the Patent Office, then the issuance of the Bond patent is persuasive that its subject matter does not fall within the tradition. The fact is that as recently as September, 1947, in a series of opinions as yet unpublished, the Patent Office Board of Appeals has ruled that the *Brinker-*

hoff case does not establish the broad doctrine asserted by petitioner. In one such case* the Board said:

> "The Brinkerhoff decision, as we read it, holds that claims involving the use of certain surgical instruments, already patented, are not patentable because such use is inherent in the article. While the exact factual situation of that case is by no means clear from the manuscript report, **we do not find therein a broad ruling to the effect that methods of treating disease are perforce unpatentable under the statute.**"

III.

PUBLIC IMPORTANCE IS NOT A GROUND FOR INVALIDATING AN OTHERWISE VALID PATENT.

Petitioner's Point V, "Public Importance," is unsound and ill conceived, if advanced as a ground for invalidating respondent's patent.

We know of no case where a patent which fulfills the statutory requirements as to subject matter and disclosures has been held invalid on the ground of public importance. On the contrary, as this Court said in *Hartford-Empire Co., et al.* v. *United States*, 323 U. S. 386, 432:

> "* * * If he (a patent owner) discloses the invention in his application so that it will come into the public domain at the end of the 17-year period of exclusive right he has fulfilled the only obligation imposed by the statute.
>
> * * * * * *
>
> "'A party seeking a right under the patent statutes may avail himself of all their provisions, and the courts may not deny him the benefit of a single one. * * * No court can disregard any statutory provisions in respect to these matters on the ground that in its judg-

* *Ex parte Tullar et al.*, Appeal No. 6999, decided September 9, 1947. A certified copy of this opinion is being lodged in the office of the Clerk.

ment they are unwise or prejudicial to the interests of the public.' *United States* v. *American Bell Telephone Co.*, 167 U. S. 224, 247."

As we have shown, the decision of the court below is in harmony with the rules established by this Court in upholding a patent for an invention which contributes "a desirable composite product which had not previously been achieved * * * and of which the public now has the benefit." Petitioner has wholly failed to sustain its burden of showing that the Bond mixed inoculant lacks the statutory prerequisites of novelty, utility and invention, and hence its contention that "public interest demands that there be no private monopoly" confirmed in Bond flies in the face of this Court's ruling in *The Telephone Cases*, 126 U. S. 1, 535, when it was said:

> "* * * It may be that electricity cannot be used at all for the transmission of speech except in the way Bell has discovered, and that therefore, practically, his patent gives him its exclusive use for that purpose, but that does not make his claim one for the use of electricity distinct from the particular process with which it is connected in his patent. It will, if true, show more clearly the great importance of his discovery, but it will not invalidate his patent."

The public is, of course, entitled to make free use of Bond's scientific discovery; but neither petitioner nor any other member of the public may make the application of that discovery which is found in the new and useful mixed inoculant defined by Bond's claims. Upon expiration of the Bond patent the public will then become fully vested with the right to make, use and sell Bond's product. If Bond had not applied for a patent but had, as was his right, kept his discovery secret, the public in that case would never come into possession of knowledge of how to make a suc-

cessful mixed inoculant. We fail to see, therefore, how "our nation's security, our prosperity and our lives" could be harmfully affected by a decision which upholds the Bond patent for a meritorious invention of a *new and useful* product.

Point V indicates more probably a realization by petitioner that, since it really seeks a retrial of the facts, the so-called legal reasons advanced in the petition for granting the writ in this case have evaporated and that this Court might well conclude that the writ was improvidently granted. *Cf. Keller* v. *Adams-Campbell Co.*, 264 U. S. 314, 319; *Layne & Bowler Corp.* v. *Western Well Works*, 261 U. S. 387, 393.

There are here no questions or principles the settlement of which are of importance to the public as distinguished from petitioner. The opinion of the court below is, as we have shown, really in harmony, and not in conflict, with the decisions of this Court; and there is no conflict among the Circuit Courts of Appeals either as to the validity of respondent's patent or as to the applicable rules of decision. Save for petitioner's contention that the industry to which respondent's patent relates is concentrated in the Seventh Judicial Circuit—a contention denied by respondent, however, and not adequately supported in the record—it should be manifest that there was no reason for granting the writ in this case.

But neither is there any basic issue of public importance raised here; this case is of no greater *moment* to the public than any other patent case. Petitioner's suggestion that "basic research in the use of bacteria in the field of medicine and industrial products as well as in the field of agriculture" is dependent upon the "correctness and soundness" of the decision of the court below, is an absurd one based wholly on petitioner's assumption, which we have

shown to be erroneous, that the court below upheld respondent's patent merely for the discovery of a law of nature.

CONCLUSION.

The court below has not improperly applied the law to the facts of this case. Its decision is correct and sound. If this Court does not dismiss the writ for having been improvidently granted, the judgment of the court below should be affirmed.

Respectfully submitted,

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APPENDIX.

PERTINENT STATUTES.

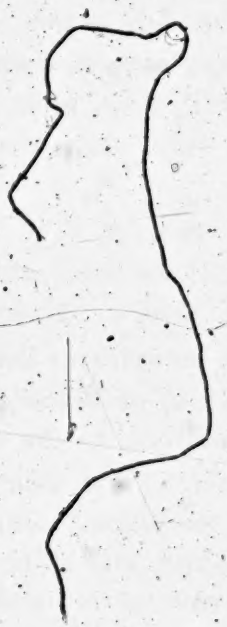
R. S. 4886, 35 U. S. C. A. § 31; March 3, 1897, c. 391, § 1, 29 Stat. 692; May 23, 1930, c. 312, § 1, 46 Stat. 376; Aug. 5, 1939, c. 450, § 1, 53 Stat. 1212.

Any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvements thereof, or who has invented or discovered and asexually reproduced any distinct and new variety of plant, other than a tuber-propagated plant, not known or used by others in this country, before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, or more than one year prior to his application, and not in public use or on sale in this country for more than one year prior to his application, unless the same is proved to have been abandoned, may, upon payment of the fees required by law, and other due proceeding had, obtain a patent therefor.

R. S. 4888, 35 U. S. C. A. § 33; July 8, 1870, c. 230, §26, 16 Stat. 201; as amended March 3, 1915, c. 94, § 1, 38 Stat. 958; May 23, 1930, c. 312 § 2, 46 Stat. 376.

Before any inventor or discoverer shall receive a patent for his invention or discovery he shall make application therefor, in writing, to the Commissioner of Patents, and shall file in the Patent Office a written description of the same, and of the manner and process of making, constructing, compounding, and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the

art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound, and use the same; and in case of a machine, he shall explain the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions; and he shall particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery. The specification and claim shall be signed by the inventor. No plant patent shall be declared invalid on the ground of noncompliance with this section if the description is made as complete as is reasonably possible.



SUPREME COURT OF THE UNITED STATES

No. 280.—October Term, 1947.

Funk Brothers Seed Company, Petitioner, v. Kalo Inoculant Company.	On Writ of Certiorari to the United States Circuit Court of Appeals for the Seventh Circuit.

[February 16, 1948.]

Mr. Justice Douglas delivered the opinion of the Court.

This is a patent infringement suit brought by respondent. The charge of infringement is limited to certain product claims [1] of Patent No. 2,200,532 issued to Bond on May 14, 1940. Petitioner filed a counterclaim asking for a declaratory judgment that the entire patent be adjudged invalid.[2] The District Court held the product claims invalid for want of invention and dismissed the complaint. It also dismissed the counterclaim. Both parties appealed. The Circuit Court of Appeals reversed, holding that the product claims were valid and infringed and that the counterclaim should not have been dismissed. 161 F. 2d 981. The question of validity is the only question presented by this petition for certiorari.

Through some mysterious process leguminous plants are able to take nitrogen from the air and fix it in the

[1] The product claims in suit are 1, 3, 4, 5, 6, 7, 8, 13, and 14. Claim 4 is illustrative of the invention which is challenged. It reads as follows:

"An inoculant for leguminous plants comprising a plurality of selected mutually non-inhibitive strains of different species of bacteria of the genus Rhizobium, said strains being unaffected by each other in respect to their ability to fix nitrogen in the leguminous plant for which they are specific."

[2] The patent also contains process claims.

plant for conversion to organic nitrogenous compounds. The ability of these plants to fix nitrogen from the air depends on the presence of bacteria of the genus Rhizobium which infect the roots of the plant and form nodules on them. These root-nodule bacteria of the genus Rhizobium fall into at least six species. No one species will infect the roots of all species of leguminous plants. But each will infect well-defined groups of those plants.[3] Each species of root-nodule bacteria is made up of distinct strains which vary in efficiency. Methods of selecting the strong strains and of producing a bacterial culture from them have long been known. The bacteria produced by the laboratory methods of culture are placed in a powder or liquid base and packaged for sale to and use by agriculturists in the inoculation of the seeds of leguminous plants. This also has long been well known.

It was the general practice, prior to the Bond patent, to manufacture and sell inoculants containing only one species of root-nodule bacteria. The inoculant could therefore be used successfully only in plants of the particular cross-inoculation group corresponding to this species. Thus if a farmer had crops of clover, alfalfa, and soy beans he would have to use three separate inoculants.[4] There had been a few mixed cultures for field legumes. But they had proved generally unsatisfactory

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[3] The six well-recognized species of bacteria and the corresponding groups (cross-inoculation groups) of leguminous plants are:

Rhizobium trifolii	Red clover, crimson clover, mammoth clover, alsike clover
Rhizobium meliloti	Alfalfa, white or yellow sweet clovers
Rhizobium phaseoli	Garden beans
Rhizobium leguminosarum	Garden peas and vetch
Rhizobium lupini	Lupines
Rhizobium japonicum	Soy beans

[4] See note 3, *supra*.

because the different species of the Rhizobia bacteria produced an inhibitory effect on each other when mixed in a common base, with the result that their efficiency was reduced. Hence it had been assumed that the different species were mutually inhibitive. Bond discovered that there are strains of each species of root-nodule bacteria which do not exert a mutually inhibitive effect on each other. He also ascertained that those mutually non-inhibitive strains can, by certain methods of selection and testing, be isolated and used in mixed cultures. Thus he provided a mixed culture of Rhizobia capable of inoculating the seeds of plants belonging to several cross-inoculation groups. It is the product claims which disclose that mixed culture that the Circuit Court of Appeals has held valid.

We do not have presented the question whether the methods of selecting and testing the non-inhibitive strains are patentable. We have here only product claims. Bond does not create a state of inhibition or of non-inhibition in the bacteria. Their qualities are the work of nature. Those qualities are of course not patentable. For patents cannot issue for the discovery of the phenomena of nature. See *Le Roy* v. *Tatham*, 14 How. 156, 175. The qualities of these bacteria, like the heat of the sun, electricity, or the qualities of metals, are part of the storehouse of knowledge of all men. They are manifestations of laws of nature, free to all men and reserved exclusively to none. He who discovers a hitherto unknown phenomenon of nature has no claim to a monopoly of it which the law recognizes. If there is to be invention from such a discovery, it must come from the application of the law of nature to a new and useful end. See *Telephone Cases*, 126 U. S. 1, 532–533; *De Forest Radio Co. v. General Electric Co.*, 283 U. S. 664, 684–685; *Mackay Radio & Tel. Co.* v. *Radio Corp.*, 306 U. S. 86,

94; *Cameron Septic Tank Co.* v. *Saratoga Springs*, 159 F. 453, 462–463. The Circuit Court of Appeals thought that Bond did much more than discover a law of nature, since he made a new and different composition of non-inhibitive strains which contributed utility and economy to the manufacture and distribution of commercial inoculants. But we think that that aggregation of species fell short of invention within the meaning of the patent statutes.

Discovery of the fact that certain strains of each species of these bacteria can be mixed without harmful effect to the properties of either is a discovery of their qualities of non-inhibition. It is no more than the discovery of some of the handiwork of nature and hence is not patentable. The aggregation of select strains of the several species into one product is an application of that newly-discovered natural principle. But however ingenious the discovery of that natural principle may have been, the application of it is hardly more than an advance in the packaging of the inoculants. Each of the species of root-nodule bacteria contained in the package infects the same group of leguminous plants which it always infected. No species acquires a different use. The combination of species produces no new bacteria, no change in the six species of bacteria, and no enlargement of the range of their utility. Each species has the same effect it always had. The bacteria perform in their natural way. Their use in combination does not improve in any way their natural functioning. They serve the ends nature originally provided and act quite independently of any effort of the patentee.

There is, of course, an advantage in the combination. The farmer need not buy six different packages for six different crops. He can buy one package and use it for any or all of his crops of leguminous plants. And, as respondent says, the packages of mixed inoculants also

hold advantages for the dealers and manufacturers by reducing inventory problems and the like. But a product must be more than new and useful to be patented; it must also satisfy the requirements of invention or discovery. *Cuno Engineering Corp.* v. *Automatic Devices Corp.*, 314 U. S. 84, 90, 91, and cases cited; 35 U. S. C. § 31, R. S. § 4886. The application of this newly-discovered natural principle to the problem of packaging of inoculants may well have been an important commercial advance. But once nature's secret of the non-inhibitive quality of certain strains of the species of Rhizobium was discovered, the state of the art made the production of a mixed inoculant a simple step. Even though it may have been the product of skill, it certainly was not the product of invention. There is no way in which we could call it such unless we borrowed invention from the discovery of the natural principle itself. That is to say, there is no invention here unless the discovery that certain strains of the several species of these bacteria are non-inhibitive and may thus be safely mixed is invention. But we cannot so hold without allowing a patent to issue on one of the ancient secrets of nature now disclosed. All that remains, therefore, are advantages of the mixed inoculants themselves. They are not enough.

Since we conclude that the product claims do not disclose an invention or discovery within the meaning of the patent statutes, we do not consider whether the other statutory requirements contained in 35 U. S. C. § 31, R. S. § 4886, are satisfied.

Reversed.

SUPREME COURT OF THE UNITED STATES

No. 280.—October Term, 1947.

Funk Brothers Seed Company, v. Kalo Inoculant Company. | On Writ of Certiorari to the United States Circuit Court of Appeals for the Seventh Circuit.

[February 16, 1948.]

Mr. Justice Frankfurter, concurring.

My understanding of Bond's contribution is that prior to his attempts, packages of mixed cultures of inoculants presumably applicable to two or more different kinds of legumes had from time to time been prepared, but had met with indifferent success. The reasons for failure were not understood, but the authorities had concluded that in general pure culture inoculants were alone reliable because mixtures were ineffective due to the mutual inhibition of the combined strains of bacteria. Bond concluded that there might be special strains which lacked this mutual inhibition, or were at all events mutually compatible. Using techniques that had previously been developed to test efficiency in promoting nitrogen fixation of various bacterial strains, Bond tested such efficiency of various mixtures of strains. He confirmed his notion that some strains were mutually compatible by finding that mixtures of these compatible strains gave good nitrogen fixation in two or more different kinds of legumes, while other mixtures of certain other strains proved mutually incompatible.

If this is a correct analysis of Bond's endeavors two different claims of originality are involved: (1) the idea that there are compatible strains, and (2) the experimental demonstration that there were in fact some compatible strains. Insofar as the court below concluded that

the packaging of a particular mixture of compatible strains is an invention and as such patentable, I agree, provided not only that a new and useful property results from their combination, but also that the particular strains are identifiable and adequately identified. I do not find that Bond's combination of strains satisfies these requirements. The strains by which Bond secured compatability are not identified and are identifiable only by their compatability.

Unless I misconceive the record, Bond makes no claim that Funk Brothers used the same combination of strains that he had found mutually compatible. He appears to claim that since he was the originator of the idea that there might be mutually compatible strains and had practically demonstrated that some such strains exist, everyone else is forbidden to use a combination of strains whether they are or are not identical with the combinations that Bond selected and packaged together. It was this claim that, as I understand it, the District Court found not to be patentable, but which, if valid, had been infringed.

The Circuit Court of Appeals defined the claims to "cover a composite culture in which are included a plurality of species of bacteria belonging to the general Rhizobium genus, carried in a conventional base." 161 F. 2d 981, 983. But the phrase "the claims cover a composite culture" might mean "a particular composite culture" or "any composite culture." The Circuit Court of Appeals seems to me to have proceeded on the assumption that only "a particular composite culture" was devised and patented by Bond, and then applies it to "any composite culture" arrived at by deletion of mutually inhibiting strains, but strains which may be quite different from Bond's composite culture.

The consequences of such a conclusion call for its rejection. Its acceptance would require, for instance in the

field of alloys, that if one discovered a particular mixture of metals, which when alloyed had some particular desirable properties, he could patent not merely this particular mixture but the idea of alloying metals for this purpose, and thus exclude everyone else from contriving some other combination of metals which, when alloyed, had the same desirable properties. In patenting an alloy, I assume that both the qualities of the product and its specific composition would need to be specified. The strains that Bond put together in the product which he patented can be specified only by the properties of the mixture. The District Court, while praising Bond's achievement, found want of patentability. The Circuit Court of Appeals reversed the judgment of the District Court by use of an undistributed middle—that the claims cover a "composite culture"—in the syllogism whereby they found patentability.

It only confuses the issue, however, to introduce such terms as "the work of nature" and the "laws of nature." For these are vague and malleable terms infected with too much ambiguity and equivocation. Everything that happens may be deemed "the work of nature," and any patentable composite exemplifies in its properties "the laws of nature." Arguments drawn from such terms for ascertaining patentability could fairly be employed to challenge almost every patent. On the other hand, the suggestion that "if there is to be invention from such a discovery, it must come from the application of the law of nature to a new and useful end" may readily validate Bond's claim. Nor can it be contended that there was no invention because the composite has no new properties other than its ingredients in isolation. Bond's mixture does in fact have the new property of multi-service applicability. Multi-purpose tools, multivalent vaccines, vitamin complex composites, are examples of complexes whose sole new property is the conjunction of the properties of their

components. Surely the Court does not mean unwittingly to pass on the patentability of such products by formulating criteria by which future issues of patentability may be prejudged. In finding Bond's patent invalid I have tried to avoid a formulation which, while it would in fact justify Bond's patent, would lay the basis for denying patentability to a large area within existing patent legislation.

SUPREME COURT OF THE UNITED STATES

No. 280.—October Term, 1947.

Funk Brothers Seed Company, Petitioner, v. Kalo Inoculant Company.	On Writ of Certiorari to the United States Circuit Court of Appeals for the Seventh Circuit.

[February 16, 1948.]

Mr. Justice Burton, with whom Mr. Justice Jackson concurs, dissenting.

On the grounds stated by the Circuit Court of Appeals the judgment should be affirmed.

When the patentee discovered the existence of certain strains of bacteria which, when combined with certain other strains of bacteria, would infect two or more leguminous plants without loss of their respective nitrogen-fixing efficiencies, and utilized this discovery by segregating some of these mutually non-inhibitive strains and combining such strains into composite inoculants, we agree with Mr. Justice Frankfurter that the combinations so produced satisfied the statutory requirements of invention or discovery.[1] These products were a prompt and substantial commercial success, filling a long-sought and important agricultural need.

However, we do not agree that the patent issued for such products is invalid for want of a clear, concise description of how the combinations were made and used. The statutory requirement is that the inventor or discoverer—

> "shall file in the Patent Office a written description of the same, and of the manner and process of making, constructing, compounding, and using it, in such full,

[1] R. S. 4886, as amended, 46 Stat. 376; 53 Stat. 1212, 35 U. S. C. § 31.

clear, concise, and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound, and use the same; and in case of a machine, he shall explain the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions; and he shall particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery . . . . No plant patent shall be declared invalid on the ground of noncompliance with this section if the description is made as complete as is reasonably possible." [2]

The completeness and character of the description must vary with the subject to be described. Machines lend themselves readily to descriptions in terms of mechanical principles and physical characteristics. On the other hand, it may be that a combination of strains of bacterial species, which strains are distinguished from one another and recognized in practice solely by their observed effects, can be definable reasonably only in terms of those effects. In the present case, the patentee has defined the combinations in terms of their mutually inhibiting and non-inhibiting effects upon their respective abilities to take free nitrogen from the air and place it in the soil. These combinations were discovered by observation of these effects—they are in practice identified by these effects for the commercial uses for which they are made. It is these effects that differentiate them from the other bacteria heretofore generally identified only as common members of the same species and not commercially valuable for use with leguminous plants of more than one of the groups named in the opinion of the Court. The identifi-

[2] R. S. 4888, as amended, 38 Stat. 958–959; 46 Stat. 376, 35 U. S. C. § 33.

cation of the strains stated in the patent is that which the patentee used in making the novel combinations of them that have been shown to be highly useful. There appears to be no question but that the petitioners are now able to identify and use the strains in the manner described in the patent. The record thus indicates that the description is sufficiently full, clear, concise and exact to enable persons skilled in the art or science to which this discovery appertains or with which it is most nearly connected to make, construct, compound and use the same. There is no suggestion as to how it would be reasonably possible to describe the patented product more completely. The patent covers all composite cultures of bacterial strains of the species described which do not inhibit each other's ability to fix nitrogen. Bacteriologists, skilled in the applicable art, will not have difficulty in selecting the non-inhibitive strains by employing such standard and recognized laboratory tests as are described in the application for this patent.

The statute itself shows that Congress has recognized the inherent difficulty presented. While this patent may not be technically a "plant patent" in the precise sense in which that term is used in this Section, the references in the Section to the differences in descriptions expected in mechanical patents and plant patents obviously support the position here taken. An inventor should not be denied a patent upon an otherwise patentable discovery merely because the nature of the discovery defies description in conventional terms. Terms ordinarily unsuitable to describe and distinguish products that are capable of description and distinction by their appearance may be the most appropriate in which to describe and distinguish other products that are not reasonably possible of identification by their appearance, but which are easily identified by their effects when being sought for or described by those skilled in the art.